Does Life Satisfaction Explain Body Mass Index?

Policy Implications of Subjective Wellbeing in Obesity Interventions

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ABSTRCT

Recently, subjective wellbeing, or more popularly, happiness and life satisfaction, have received growing interest from social scientists, policy makers, and the public alike. This thesis applies Wellbeing, Self-determination, and Social Cognitive theories, and investigates the role of subjective wellbeing for obesity. The main methodology is multivariate regression with ordinary least square, Logit, and two-stage least square estimators. The data are from the Canadian Community Health Survey, 2010. Results show that subjective wellbeing has negative, independent impact on body mass index (BMI) and on the probability of being obese after controlling for the conventionally studied determinants of obesity like age, gender, income, and education. The study contributes to the literature on obesity and suggests possible policy interventions on obesity from the perspective of subjective wellbeing.

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Chapter 1
INTRODUCTION

Governments around the world are increasingly showing interest in the level of citizens' subjective wellbeing, often measured by life satisfaction, happiness, etc. Subjective wellbeing is popularly treated as one of the ultimate goals of policies. For example, a consensus has emerged in France, the United Kingdom, the United States, and many other countries that the primary goal of public policy should be the "greatest happiness" rather than the "greatest wealth" (Forgeard et al. 2011; Michaelson et al. 2009, 15). Famously, since 1972, Bhutan has abandoned measuring gross national income and has declared "gross national happiness" as its overarching policy goal (Angner 2011; Bernanke 2012). The Stiglitz Commission, set up by former French president Nicolas Sarcozi, has given a reason for this worldwide concern and concluded, "…the time is ripe for our measurement system to shift emphasis from measuring economic production to measuring people's wellbeing. Emphasizing well-being is important because there appears to be an increasing gap between the information contained in aggregate GDP data and what counts for common people's well-being" (Stiglitz, Sen, and Fitoussi, 2009, 12).

In addition to being treated as a policy objective, subjective wellbeing is increasingly recognized as a down-stream policy instrument for general wellbeing of individuals. The recent *World Happiness report 2013* of the United Nations has summarized many empirical examples and concluded that happier and satisfied people are more likely to be healthier, productive, and pro-social. These benefits have resulted in better and flourishing families, workplaces, and communities. Here happiness is thus primarily considered as a means — rather than an *end* in itself (Helliwell, Layard, and Sachs 2013).

The recent psychological literature suggests that subjective wellbeing is particularly important for predicting good health behaviour (Helliwell, Layard, and Sachs 2013, 57), because it indicates happiness, satisfaction, or other positive or desirable mental states as expressed by individuals *themselves* (Angner 2011; Layard 2005; Seligman 2011) and this self-reported wellbeing is the underlying motive of all human behaviour (Angner 2005; Hoorn 2009; Walsh 2005). For example, people with low subjective wellbeing are more likely to be physically inactive, eat more, and carry risks of poor health outcomes including obesity (Bandura 1989, 1999; Friedli 2009; Helliwell, Layard, and Sachs 2012, 2013).

This study primarily investigated how subjective wellbeing affects obesity. Obesity in Canada has become a public health concern costing the economy $4.6 to $7.1 billion every year. In a Statistics Canada (2012) survey, about 18.4 percent and 34.1 percent of the Canadian population was classified as obese and overweight respectively.[1] In the last decade (2003–2012), this prevalence of obesity and overweight has been rising, and the rate of rise is higher among children and youth than the other age groups. The obese and overweight often have costly chronic health problems such as coronary heart disease, stroke, cancer, and diabetes, and the obesity problem contributes to problems like missed days of work, decreased productivity, disability, and premature death, among others (Friedli 2009). Additionally, the obese population suffers from social stigma when they encounter stereotyping, discrimination, and lower levels of support in social settings (Public Health Agency of Canada (PHAC) 2011).

People become obese as a result of long-term dysfunction in health behaviours such as physical activity and eating habits. When people take in more energy through eating but expend less through physical activity, caloric imbalance ensues and leads to weight gains (Swinburn,

[1] This obesity prevalence rate is based on Body Mass Index (BMI) of individuals. BMI is calculated as the ratio of weight to squared height. If a person's BMI is between 25 and 29.99 kg/metre^2, the person is overweight and if BMI is 30 kg/metre^2 or above, the person is obese. The use of BMI as a measure of obesity level will be discussed in more detail in Chapter 4.

Egger, and Raza 1999). Obesity literature has shown that these eating and physical activity behaviours are influenced by sets of personal, social, and environmental factors, such as, "who the person is" —genes, age, gender, race, etc. (Macintyre 2007, 30); "what the person has" — income, education, etc. (McLaren and Godley 2009); "which group the person belongs to" — family, friends, peers, etc. (Story et al. 2008); and "where the person lives" —neighbourhood, parks, sidewalks, markets, etc. (Sallis, Bauman, and Pratt 1998).

Health behaviours also depend on personal psychological factors including "how people think about their lives" — something the obesity literature has paid little attention to (Canadian Medical Association 2007). When individuals are asked to assess their own wellbeing, they count aspects of their lives that are satisfying including job or working conditions, housing, financial situation, leisure, work–life balance, family, friends, neighbourhood, etc. When individuals are satisfied, they feel happy and remain productive; conversely, when they are unhappy, they engage in unproductive health behaviours with consequent poor health outcomes like obesity (Helliwell, Layard, and Sachs 2012; Raphael 2006).

This psychosocial pathway to obesity can be explained by three psychology theories. Wellbeing Theory and its predecessor Self-determination Theory (SDT) suggest that individuals with high subjective wellbeing autonomously function well and are not likely to initiate health-threatening behaviours such as overeating, physical inactivity, smoking, drinking, etc. (Deci and Ryan 2000; Seligman 2011). The resilience or psychological strengths of these individuals also help them deal with stress effectively, and refrain from resorting to health-threatening behaviours as solutions (Friedli 2009, 24; Michaelson et al. 2009). Another psychology theory, the Social Cognitive Theory, suggests that human beings follow others in the society and use emotional short-cuts to solve problems. For this reason, the social context can reinforce or weaken

psychological strengths that govern individuals' health behaviours (Bandura 1989, 1999; Helliwell, Layard, and Sachs 2012).

However, the empirical knowledge of the exact direction of the causality between subjective wellbeing and obesity is still incomplete. Citing empirical evidence that is discussed in detail in chapter three, Helliwell, Layard, and Sachs (2012; 2013) have argued that greater happiness predicts health behaviours and health, often through mediating psychological concerns like, stress, depression etc. However, there are also possibilities of the causal relationship being run in the opposite direction (see Kivimaki et al. 2009). For example, obese people may suffer psychological concerns that affect subjective wellbeing (Garg et al. 2007; Friedlander et al. 2003, 5; Katsaiti 2009; PHAC 2011, 27; Strine et al. 2008 a and b). Despite the possible two-way causality between obesity and subjective wellbeing, none of these studies surveyed was found to involve Canadian data in examining the exact role of subjective wellbeing for obesity. Therefore, a literature gap exits.

The objective of this study was to use Canadian data to fill this literature gap by applying the psychology theories discussed above and empirically investigating the following question: Does subjective wellbeing have an independent negative impact on an individual's level of obesity? The main methodology is multivariate regression with ordinary least square and Logit estimators. In addition, instrumental variable two-stage least square estimator was used to separate out the independent exogenous impact of subjective wellbeing on obesity from the feedback effect of obesity on subjective wellbeing. The estimation equation included subjective wellbeing measures like life satisfaction and cognitive health, demographic and socioeconomic variables, peer group influence indicators, and provincial fixed effects. Data were taken from the Canadian Community Health Survey, 2010 Public Use Micro data File.

This study has found that even after accounting for the effect of demographic, socioeconomic, and other factors, subjective wellbeing—represented by life satisfaction—had independent negative effects on obesity. This finding supports the concepts of Wellbeing Theory and Self-determination Theory. This study has also found that the social norms and environmental context—represented by peer groups — affects individuals' obesity level, which is consistent with the Social Cognitive Theory.

This thesis is organized as follows: chapter 2 reviews the existing knowledge on obesity and subjective wellbeing; chapter 3 describes the theoretical foundation for the relationship between subjective wellbeing and obesity; chapter 4 presents the data and methodology; chapter 5 discusses the estimation results; and finally, chapter 6 concludes with policy implications.

Chapter 2
LITERATURE REVIEW
(Background and Existing Knowledge)

This chapter summarizes the causes and determinants of obesity and provides an introduction to the definition, measurement, and policy implications of subjective wellbeing—a new dimension in individuals' personal psychological state, which may have far-reaching impact on individuals' health behaviours and health outcomes compared to other factors.

2.1 Understanding Obesity:

2.1.1 Origin of Obesity

Obesity is a complex phenomenon. Swinburn, Egger, and Raza (1999) and Story et al. (2008) have presented an ecological model to understand obesity. The ecological model argues that both personal and environmental factors interact to influence health behaviours (eating habits and physical activity), which in turn determine the energy input, the energy output, and the equilibrium fat store. Fat store increases and obesity develops when energy imbalance ensues, i.e., when the person takes in more calorie-dense food, but expends fewer calories through physical activity.

2.1.2 Determinants of Obesity

Public Health Agency Canada (PHAC 2011) reported two subsets of risk factors that affect obesity at the population level: (1) health behaviours, such as leisure time physical activity, fruit and vegetable consumption, smoking status, and alcohol consumption; and (2)

social determinants, such as immigrant status, visible-minority status, household income, urban vs. rural residence, and marital status.

Among all the factors, physical activity has the strongest association with obesity (PHAC 2011, 26). Physical activities include activities of daily living, occupational or work-related activities, active commuting, and incidental movement. Obesity is also associated with unhealthy eating habits including low consumption of fruits and vegetables, excess consumption of energy-dense food (such as rice and wheat flour), eating or snacking while watching television, skipping breakfast, taking soft drinks between meals, etc. (PHAC 2011).

Previous empirical studies on obesity have found that individual personal factors such as gender, age, and marital status affect obesity. In particular, men, the elderly and married people are more prone to obesity than their counterparts (Tjepkema 2005; Shields et al. 2010, 1–15; PHAC 2011, 6, 18–21). Moreover, income level and occupational image are inversely associated with obesity in women, a pattern not seen in men (McLaren and Godley 2009). Education is negatively associated with obesity irrespective of gender, but for women, the relationship between occupational image and BMI is largely attributable to education (McLaren 2009; PHAC 2011, 6, 18–21).

At the community level, health behaviours are profoundly affected by the social norms, cultural beliefs and values, and attitudes within individuals' peer groups. For example, a study by Garriguet (2008) has shown that the increased rates of obesity in Aboriginal than non-Aboriginal populations in Canada is attributed to attitude and norms of taking in more carbohydrates, fat, and sodium, taking in less protein, and spending less leisure time actively. Moreover, a study in the Netherlands has noted that Indian immigrants attach importance to traditional eating habits (taking more potatoes); tend to underestimate the seriousness of obesity-related consequences

such as Cardiovascular disease and feel that they are not very susceptible to it; attribute illnesses to chance-related factors, fate, or karma (belief that illnesses are caused by cosmic forces); and want to preserve their own tradition and use different coping strategies to deal with illnesses (Hendriks et al. 2012).

On the other hand, the "deprivation amplification hypothesis" claims that residents living in poorer areas have more physical barriers to overcome to become physically active (Sallis, Bauman, and Pratt 1998). The low socioeconomic-status groups report lower proximity to recreational facilities in their neighbourhood and less access to walking or jogging trails, indoor activity places, treadmills, parks, etc. In addition, low socioeconomic neighbourhoods have limited access to healthy food (fresh fruit, vegetables, and fish); for example, these neighbourhoods have fewer food stores that serve healthy food, and more convenience stores and fast food outlets (Macintyre 2007, 30; Swinburn et al. 2004, 133; Taylor et al. 2006).

In addition to differences in individual characteristics and social environment, Sallis, Bauman, and Pratt (1998) and Story et al. (2008) have argued that the institutional environment also has a substantial influence on health behaviours and obesity. The institutional environment includes research grants, infrastructural investments, and subsidies that support production of energy-dense food rich in trans-fat and sugar versus the policies that support production of fresh fruit and vegetables, and strategies that regulate marketing and advertising of energy-dense food geared to children and youth. Similarly, building codes, urban planning and zoning, etc., are also important policies that affect physical activity and obesity.

2.2 Understanding Subjective Wellbeing

2.2.1 The concept of wellbeing:

The United Kingdom Government Foresight Review has defined wellbeing as "a dynamic state, in which the individual is able to develop their potential, work productively and creatively, build strong and positive relationships with others, and contribute to their community" (Michaelson et al. 2009, 18).

The wellbeing literature identifies two approaches to wellbeing: (1) the hedonic approach, which considers wellbeing as "positive feeling" or "positive affect" and (2) the eudaimonic approach, which considers wellbeing as "positive functioning" (engagement, fulfillment, sense of meaning and purpose, social wellbeing, etc.). Both approaches are important for human "flourishing" (Friedli 2009; Michaelson et al. 2009).

Another way to understand wellbeing is to categorize it into three dimensions as done by the European Social Survey (2006), conducted in 22 European countries. The three dimensions are personal wellbeing, social wellbeing, and wellbeing at work (Michaelson et al. 2009).

Personal wellbeing is made up of a subset of five components: (1) emotional wellbeing—a balance between positive and negative feelings, often measured by happiness, (2) life satisfaction—positive evaluation of life by individuals, (3) vitality—having energy, feeling well-rested and healthy, and being physically active, (4) self-esteem—feeling good about self, optimism—feeling optimistic about future, and resilience—feeling capable to deal with life difficulties, and (5) functioning—competence, autonomy, engagement, and meaning. The first two components refer to personal psychological wellbeing, which is also referred to as "mental capital" by the United Kingdom Government Foresight Review.

Social wellbeing is made up of a subset of two components: (1) supportive relationships—the extent and quality of interactions with "who the person belongs to" such as family members, close friends, relatives, and others on the basis of reciprocity, and (2) trust and belonging—having trust in others, being treated fairly and respectfully in the society, and feeling a sense of belonging to "where the person lives." Social wellbeing is referred to as "social capital" by Helliwell (2011), Helliwell, Layard, and Sachs (2012), Helliwell and Wang (2011), and Stiglitz, Sen, and Fitoussi (2009). Social wellbeing or social capital is often measured by family ties, number of close friends and relatives, and membership and participation in religious and voluntary organizations (Bandura 1999; Friedli 2009).

The last dimension of wellbeing, wellbeing at work, is represented by job satisfaction, working conditions, work–life balance, etc.

As all the three dimensions of wellbeing measured by the European Social Survey are self-reported wellbeing, they are considered as subjective measures of wellbeing, or subjective wellbeing. Wellbeing also depends on objective factors like income, education, etc., or economic wellbeing. While both objective and subjective factors are important for assessing wellbeing, Michaelson et al. (2009) argued that it is the subjective wellbeing that is not measured frequently by national governments despite the fact that subjective wellbeing has, as Friedly (2009) noted, a far-reaching impact on human behaviour.

2.2.2 Measures of subjective wellbeing:

Subjective wellbeing is people's positive evaluations of their lives that include positive emotion, engagement, satisfaction, and meaning (Diener and Seligman 2004). Helliwell, Layard, and Sachs (2012) have referred to subjective wellbeing as the general expression used to cover a range of individual self-reports of moods and life assessments. Subjective wellbeing is thus

represented by life satisfaction, happiness, or other positive or desirable mental states and regarded as the underlying motive of all human behaviours (Angner 2005, 2011; Hoorn 2009; Walsh 2005).

Previous studies have reported two aspects of subjective wellbeing: the affective part captures the day-to-day joy of friendship, leisure time with family, the downside of long work hours, relation with one's boss, etc., and the evaluative part reflects overall satisfaction or frustration with one's position in the society. The affective part of subjective wellbeing is thus measured by happiness questions, for example, "taking all things together, how happy would you say you are;" while the evaluative part is often measured by life satisfaction questions, for example, "all things considered, how satisfied are you with your life as a whole nowadays" (Dolan, Layard, and Metcalfe 2011; Helliwell, Layard, and Sachs 2012; Hoorn 2009).

2.2.3 Determinants of subjective wellbeing:

Empirical studies have found that subjective wellbeing is primarily influenced by personal factors such as health status, income, family life and intimate relationships, and social connection (Bönke 2005; Dolan, Peasgood and White 2008; Helliwell 2009; Layard 2005; Lucas 2007). Helliwell, Layard, and Sachs (2013, 41) have argued that people can be unhappy for many reasons— from poverty to unemployment to family breakdown to physical illness. While poverty, poor mental health, and deep division in the community contribute to low life satisfaction, higher income, better mental health, and a high degree of trust in one's community contribute to high life satisfaction,

The effect of income on life satisfaction, however, fades as people adapt to rising income over time (Forgeard et al. 2011, 2). Rather, trust in the workplace, in the police, and among neighbours, etc. influences subjective wellbeing more than income does, and this effect is often

mediated through sense of belonging to local and broader communities and related identities (Helliwell and Wang 2011). Helliwell, Layard, and Sachs (2012), and Helliwell and Barrington-Leigh (2010) have also argued that although basic living standards are essential for happiness, particularly for poorer communities, after the baseline is met, happiness depends more on social trust (social capital), because trust within the community enhances distribution of resources and improves cohesion and co-operation of the community for mutual benefit.

In addition, the literature also identifies the other factors that are correlated with life satisfaction including close friends (Helliwell and Wang 2011, table 3), availability of someone to count on in times of trouble, availability of food and facilities like running water, governance quality (Helliwell 2008), democratic or civic engagement (Frey and Stutzer 2000), safety and security (Fleche, Smith, and Sorsa 2011), low inflation (Di Tella, MacCulloch, and Oswald 2001).

2.2.4 Policy implication of subjective wellbeing as a policy means:

Subjective wellbeing is considered as an important factor for the purposes of articulation, implementation, and evaluation of public policy. In the *World Happiness Report*, Helliwell, Layard, and Sachs (2012) have argued that whether people are happy and satisfied with various life aspects offers important information about society—it can signal underlying crises or hidden strengths, and can suggest a need for change.

Subjective wellbeing fosters good policy outcome and offers benefits in many domains of life including health. A time-series study by Lyubomirsky, Sheldon, and Schkade (2005) have established that with high levels of subjective wellbeing, people are creative and more social, spend more time doing volunteer work, have higher income and better supervisory evaluations, are less likely to suffer unemployment, are more likely to get married (happily) and to remarry

after divorce, have better longevity and lower suicide rate, drink less alcohol and smoke less, have lower general health risks, and have a better chance of surviving conditions such as coronary heart disease.

Happiness can influence health and other socioeconomic outcomes both directly and indirectly (Helliwell, Layard, and Sachs 2013). For example, strong social connection and the resulting greater happiness promotes health by enabling individuals to encounter stress effectively. Greater social cooperation, motivation, and creativity are instrumental to success in business, and in life as a whole. Depression creates illness, provokes quitting one's job frequently, and reduces success in the workplace. Moreover, places with higher life satisfaction have greater life expectancies (Lawless and Lucas 2011). Higher levels of national well-being is related to lower levels of national hypertension (Blanchflower and Oswald 2008), and low subjective well-being is both a short- term and long-term predictor of suicide (Moum 1996).

Since happiness depends more on social trust (social capital) than income, policies for improving subjective wellbeing in general should include fostering a strong community with high employment, better working condition, and high levels of trust and respect (Helliwell 2011). Helliwell, Layard, and Sachs (2012) have also maintained that national governments can achieve those objectives through inclusive participatory policies, improving physical and mental health, supporting family life, and ensuring a decent education for all. Moreover, as the authors put it, gross national product is a valuable goal, but should not be pursued to the point where economic stability is jeopardized, community cohesion is destroyed, the vulnerable are not supported, ethical standards are sacrificed, or the world's climate is put at risk, which all are required for enduring happiness of the society. Finally, Helliwell (2011, 12) has argued that improving

subjective wellbeing by way of improving positive state of mind and social interaction delivers better health outcome at a lower cost.

Chapter 3
THE THEORETICAL FRAMEWORK

This chapter will first briefly summarize three theories of subjective wellbeing, and then describe how the theories can be applied to understand obesity.

Among the three theories, the Self-determination Theory, and the Wellbeing Theory as a subset, focus at the individual level, and emphasize that human behaviour is self-determined or autonomous; while Social Cognitive Theory focuses mainly at the community level, and claims that health behaviours are controlled by the social norms, attitudes, beliefs, and values of the peers, and are influenced by other surrounding environmental context external to an individual.

3.1 The Self-determination Theory and the Wellbeing Theory

3.1.1 A description of the Self-determination Theory and the Wellbeing Theory

Self-determination Theory (SDT) is built on the premise that to be productive, creative, and sustainable, behaviours should be autonomous, and behavioural decisions should come from internal motivation. SDT posits that behaviours become autonomous when three innate psychological needs—autonomy, competence, and relatedness—are met. These needs are important for ongoing psychological growth, integrity, and wellbeing (Deci and Ryan 2000). *Autonomy* means the person should have the freedom to freely process, endorse, and, if needed, modify the transmitted social value. A feeling of *competence* refers to a feeling of the ability to grasp the rationale behind the regulation being internalized, and the ability to perform socially desired behaviour. *Relatedness* means high social support and low control or social pressure. SDT claims that behaviours satisfying the three innate psychological needs are autonomous,

intentional, intrinsically self-rewarding and self-motivating, and are sustained over a long term (Deci and Ryan 2000; Lyubomirsky 2008; Teixeira, Patrick, and Mata 2011).

The Wellbeing Theory, which is built on SDT, argues that people satisfy the innate psychological needs of autonomy, competence, and relatedness through nurturing five psychological strengths: *positive emotion, engagement and flow, relationship, meaning* and *purpose*, and *accomplishment* (PERMA)—the five decomposed domains of the wellbeing construct (Forgeard et al. 2011; Seligman 2011). *Positive emotion* means feeling good and not feeling bad, in other words, happiness. *Engagement* refers to a psychological state in which individuals report being absorbed by and focused on what they are doing. At its high end, engagement is referred to *"flow"* or "being in the zone", such that the individual becomes completely immersed in what he or she is doing. *Relationship* is referred to as the belief that one is cared for, loved, esteemed, and valued in the society. *Accomplishment* is defined in terms of reaching a desired state and progress toward goals. *Meaning and purpose* refers to feeling of belonging and serving something larger than the self (see Forgeard et al. 2011 for further details).

One important connection between the two theories is that good relationship or social support is required for internalizing socially desired norms, and performing any behaviour with full autonomy. When people feel or evaluate that they are loved and cared for, and that their views are valued in the society, they enjoy autonomy or freedom in choosing activities that match their level of competence. In this regard, Forgeard et al. (2011, 9) have stated, "Social support—the belief that one is cared for, loved, esteemed and valued—has been recognized as one of the most (if not the most) influential determinants of wellbeing for people of all ages and cultures." This social support helps people feel well and esteemed, motivates them internally,

and strengthens them psychologically. As a result, people generate intrinsic aspirations from inner self, completely engage and immerse in what they do, accomplish what they want, and feel a sense of belonging to the community. Better sense of belonging in turn helps people internalize social regulations and function productively for their own sake, and for the greater interest of the community. In this way, individuals become happy and satisfied in life and flourish to reach their potential (Forgeard et al. 2011; Michaelson et al. 2009).

In sum, subjective wellbeing refers to individual's internal psychological strength to remain creative and productive, and to refrain from unproductive behaviour, and subjective wellbeing depends to a large extent on social support.

3.1.2 How the Self-determination Theory and Wellbeing Theory help understand obesity

The Self-determination Theory and Wellbeing Theory suggest that if individuals are given *autonomy* or freedom of choice that matches their *competence* level, they become happy and satisfied with life, psychologically strong or resilient, and feel motivated internally to behave productively and creatively for their own sake and for the greater interest of the community. When things go wrong, they use their resilience to buffer stress and refrain from health-threatening behaviours (physical inactivity, overeating, smoking, drinking, etc.). Therefore these theories suggest that the level of subjective wellbeing has negative association with health-threatening behaviours and obesity.

3.2 The Social Cognitive Theory

3.2.1 A description of the Social Cognitive Theory

Social Cognitive Theory (SCT) focuses on the effects that others or the surrounding environment have on the person's behaviour. The theory emphasizes that individuals strive to learn and follow socially desired behavioural patterns, and they can perform socially learned behaviours to the extent they feel capable of carrying out those behaviours (Bandura 1977b, 1989). The theory specifically focuses on "reciprocal determinism;" in other words, the interactive process by which personal cognitive factors and environmental factors affect each other to determine human behaviour.

The core concepts of SCT include five subcategories: *psychological determinants of behaviour, environmental determinants of behaviour, observational learning, self-regulation*, and *moral disengagement* (Bandura, 1997; Glanz, Rimer, and Viswanath 2008).

Psychological determinants of behaviour involve cognitive skill and ability for emotional adjustments. One of its elements is outcome expectation, which means individuals are rational and strive to maximize benefit and minimize cost. However, the theory also recognizes that individuals' actions are not always objective and rational; rather, individuals try to fit in their community, and follow socially desired norms or behaviour. The other element of the psychological determinants of behaviour, self-efficacy belief, posits that following socially desired behaviours depends on people's beliefs about their personal ability to perform those behaviours (Bandura 1997).

Environmental determinants of behaviour include, first, the social environment, in other words, "who the person belongs to." Social environment is proximal to the person and includes family members, friends, peers, and colleagues, with whom individuals share emotional

attachment, commonalities or cultural ties, or other forms of identity. The theory emphasizes that the social and cultural norms, peer pressure, etc., have profound effect on the person's behaviour. Thus, the surrounding social and cultural contexts can either encourage or discourage productive behaviours (Bandura 2002). Environmental determinants of behaviour also include the physical environment, or "where the person lives," such as neighbourhood characteristics, parks, restaurants, characteristics of rural-urban settings, etc. For example, readily available parks and sidewalks motivate and enable people to remain physically active.

The *observational learning* concept is based on the fact that people imitate or follow the behaviour modeled by those they identify with or with whom they are culturally attached. The *observational learning* concept provides the basis for popular public health intervention strategies to modify health behaviour (Bandura 1997). Public health interventions use observational learning programs such as peer modeling, coping models, and behavioural journalism. These programs create social norms, and persuade and motivate people by presenting success stories of peers, coping or role models, and community leaders.

People also discount immediate cost and short-term benefit to achieve long term goals—another concept termed as *self-regulation*. The SCT posits that social support or encouragement is necessary for self-regulation.

In the self-regulatory mechanism behaviours are regulated by cognitive reasoning and a set of moral standards (Bandura 1986, 1991b). But in stressful situations, emotional arousal reduces moral or cognitive reasoning (outcome expectation) and self-efficacy. In this pathway *moral disengagement* from standards of self-regulation ensues, and people adopt self-harming practices, like smoking, excessive drinking, overeating, inactivity, etc.

3.2.2 How the SCT concepts help understand obesity

The *environmental determinants* and *observational learning* concepts in SCT together explain why health behaviour and health outcome vary by culture and region. People tend to fit in with whatever group they most strongly identify with. As people follow desired behaviours set up by "who they belong to," health outcome varies by social or peer groups, ethnicity, and race. For example, people may feel pressure from their social class or peer groups to perform certain behaviours such as being physically active or inactive, eating high fiber and cooked food rather than fast food, etc. Similarly, people shape their behaviour in order to fit in "where they live." For example, absence of amenities in rural remote area may give certain peer groups a sense that they are environmentally deprived or challenged to remain physically active or do not have access to fresh food. Conversely, groups with better amenities may feel encouraged to walk and remain physically active.

Still other people with certain level of *psychological determinants* are often misguided by incomplete and erroneous information from the surrounding environment (for example, fast-food commercials), and make irrational health choices. These people suffers from cognitive bias, misperceive the world around them, and consider the health behaviours they pursue as rational (Bandura 1989, 10) —a situation that Parraga (1990) labeled as the cognitive or mental representation of the environment.

The *self-regulation* and *moral disengagement* concepts of SCT also help explain why psychological strength as suggested by the Self-determination Theory and the Wellbeing Theory matter for obesity. Even when people know what is right, some may disengage from moral standards of self-regulation and choose health-threatening behaviours to get temporary relief from day-to-day stress (Bandura 1999, 16; Friedly 2009; Stiglitz et al. 2009, 51–55). For

example, experience of unequal socioeconomic personal status produces chronic psychological stress and feelings of shame, worthlessness, and envy. In an attempt to alleviate these feelings of shame and worthlessness, individuals overspend, take on additional jobs, and adopt health-threatening behaviours such as overeating and use of alcohol and tobacco (Raphael 2006). As a result, obesity develops.

In summary, the three theories suggest that, both the subjective wellbeing of individuals and people's interaction with the social environment matter for health behaviour. As people have a tendency to observe, learn, and follow socially desired norms, particularly from peers with whom they have cultural or other ties, the values, attitudes and practices of those groups may encourage or discourage certain health behaviours. Therefore, if the SDT and Wellbeing theory can be used to explain health behavior at the individual level, the SCT theory can be used to explain the community-level influence on health behaviour through peer pressure.

3.3 The knowledge gap in the literature of obesity

Although the three theories summarized above suggest subjective wellbeing and peer pressure have profound effects on health behaviour, the obesity literature has paid little attention to the role of psychological aspects of human beings (Raphael 2006).

Empirical studies suggest that there is a possible two-way causal relationship between subjective wellbeing and health behaviours (see Gallup World Poll 2010; Gatineau and Dent 2011, 5–6; Helliwell, Layard, and Sachs 2013; Kivimaki et al. 2009 for a review). On one hand, subjective wellbeing affects health behaviors. For example, higher life satisfaction is associated with a greater likelihood of exercising (Grant, Wardle, and Steptoe 2009) and intake of healthier food like fruits and vegetables (Blanchflower, Oswald, and Stewart-Brown 2012). Subjective

wellbeing also affects health behaviours indirectly through mediating factors such as adversity and stress; for example, distressed adolescents are more likely to be overweight (Kubzansky, Gilthorpe, and Goodman 2012); sad (depressed) people are more likely to eat unhealthy fatty foods (Garg, Wansink, and Inman 2007), are likely to exercise less and are more likely to be obese (Strine et al. 2008 a, b; Kivimaki et al. 2009). Moreover, positive feelings harness the immune system and protect from chronic inflammation and infection, and lead to fewer cardiovascular problems like coronary heart diseases.

Conversely, health behaviour and outcome also affect subjective wellbeing. Healthier eating and exercise behavior predict life satisfaction in college students (Pettay 2008). Moderate exercise affects happiness in adolescents (Schneider et al. 2009), and body weight affects self-esteem (Friedlander et al. 2003, 5; PHAC 2011, 27). Katsaiti (2009) has also found that the disability associated with obesity affects subjective wellbeing.

As the subjective wellbeing literature is still new (Angner 2011; Fleche, Smith, and Sorsa 2011, 7; Hoorn 2009), the exact casual direction between subjective wellbeing and obesity still remains uncovered. Empirical evidences of the direct and independent impact of established subjective wellbeing measures on obesity, as suggested by the three theories summarized earlier, involving Canadian data is lacking. Therefore a literature gap exists.

A clinical practice guideline by the Canadian Medical Association (2007, 11) advocated the necessity of closing this knowledge gap. In the next chapter, I will use various multiple regression models and methods to investigate whether subjective wellbeing has an independent negative impact on obesity using the Canadian data, in an effort to close this knowledge gap.

Chapter 4
DATA AND METHODOLOGY

The wellbeing constructs discussed in the previous chapter suggest that subjective wellbeing measures are expected to explain variance in obesity on top of the other conventional factors summarized in chapter two. In addition, peer groups should influence health behaviours of individuals at the community level. This chapter will apply these theories and introduce various multiple regression models and methods to explain obesity.

4.1 The estimation model

The primary aim of this study was to investigate whether subjective wellbeing has an additional and negative effect on obesity through its influence on health behaviors, after accounting for the effect of other covariates including income, education, etc. A reduced form model rather than a complicated structural model is used here because the association between BMI and health behaviours has been confirmed by numerous previous empirical works (see a systematic review of 213 empirical works on obesity in PHAC 2011, 17–18). Regressions involving the sample data of this study also show that subjective wellbeing affects physical activity and eating habits, and physical activity and eating habits affect BMI (see Tables A3 in the Appendix for the results). Therefore, for the purpose of easy construction and estimation, this study used a reduced form model.

The following estimation equation was constructed from the variables described in the data section below:

$$\textit{Obesity measure} = \alpha + \beta_1 \textit{(subjective wellbeing variables)} + \beta_2 \textit{(demographic and socio-economic variables)} + \beta_3 \textit{(peer group and provincial fixed characteristics)} + \varepsilon$$

(1)

4.2 Data source

The Canadian Community Health Survey (CCHS) provided the source of data for this study. The survey collected data on health behaviours and health outcomes from a total of 62,000 respondents from all the provinces and territories in Canada. CCHS included data of obesity measures such as BMI; measures of health behaviours such as physical activity and food intake; measures of subjective wellbeing, for example, life satisfaction in general and in various life domains (neighbourhood, housing, job, family, friends, etc); emotional health (derived through happiness questions); and cognitive health. The survey also held data on demographic, socio-economic, and environmental characteristics of individuals including age, gender, income, education, visible-minority status, health region, province, etc. CCHS data have been used by governments, non-profit organizations, and academia for population health research including, for example, Canadian Institute of Health Information (2009), McLaren and Godley (2009), Parliament of Canada (2007), and Sari (2010). This study used the 2010 wave of the CCHS survey as the data source because this was the latest public-use micro data when this study was initiated.

4.3 Description of the dependent variable

4.3.1 The use of BMI as a measure of obesity

Body Mass Index (BMI) was chosen as the major indicator of obesity level and as the main dependent variable in this study.

BMI is defined as an individual's weight in kilograms divided by the square of the height in metres. Since the mid-1990s, Statistics Canada's two major health surveys, CCHS and the

National Population Health Survey, have generally relied on respondents to report their weight and height, and used these data to calculate BMI. According to the World Health Organization and Health Canada guidelines (*Canadian Guidelines for Body Weight Classification in Adults*), a person above 18 years of age or older (excluding pregnant women) having a BMI equal to or more than 30 kg/metre^2 is considered obese. Overweight, normal weight and underweight persons have a BMI of between 25.00 and 29.99, between 18.50 and 24.99, and below 18.5 respectively (Health Canada 2003).

Self-reported BMI has a number of limitations as it doesn't give a precise estimate of percentage distribution of body fat, and thus cannot be used to accurately assess health risks of individuals (Health Canada 2003; Singer-Vine 2009; Stommel and Schoenborn 2009). For example, BMI can be quite different for a man and a woman with the same percentage of body fat. Further, BMI can be very different in muscular or lean males compared to other people of the same height, weight, and age; and in seniors compared to young and middle-aged adults (Health Canada 2003). Health risks associated with certain BMI level can also be different across ethnic groups. For example, Asians have different body build, have greater percentage of body fat, and carry greater health risk even with a BMI between 23 and 24 compared to their European and White counterparts, suggesting that the BMI threshold of 25 for normal weight may be too high for some Asians (Health Canada 2003, 18; Tremblay et al. 2005, 29). Moreover, BMI may not be useful when assessing mortality associated with obesity-related illnesses such as hypertension and diabetes (Jerant and Franks 2012).

Also, self-reported BMI as used in this study may have measurement errors. When compared to actual BMI, self-reported BMI shows that women are inclined to underestimate their weight, while men tend to overestimate their height. A report by Shields, Gorber, and

Tremblay (2008, 10) have found that the obesity rate was 7.4 percentage points higher when measured height and weight were used to calculate BMI than when self-reported data were used. Moreover, Stommel and Schoenborn (2009) have found that younger and older respondents underestimate their BMI more than respondents aged 42–55. However, they also maintained that BMI values based on self-reported height and weight—if corrected for the biases associated with socio-demographic characteristics of the survey respondents—can be used to estimate health risks associated with obesity, particularly when parametric prediction models are used.

Although there are a few other measures of obesity used by physicians when they assess health risks of patients including waist circumference, waist-hip ratio, body fat percentage, etc. (Jeremy 2009), and in spite of the limitations of self-reported BMI, BMI remains a useful and popular measure of obesity in health and policy world (Han, Sattar, and Lean 2006), particularly when a large population is studied (Medical News Today 2013). For example, the World Health Organization and Health Canada have used BMI to assess the health risks of obesity (Health Canada 2003). For this reason, and because CCHS does not provide data of alternative measures of obesity other than BMI, this study will use BMI as the main measure of obesity.

4.3.2 The characteristics of BMI in the sample data

The BMI data for three population groups are available in the CCHS 2010: (1) adults between 20 and 64; (2) adults aged 18 and over; and (3) children aged 12 to 17. The first group (20–64 year old) was chosen for this study, because BMI for this group is a continuous measure, while BMI for the other two groups are categorical measures (values: 1 – underweight, 2 – normal weight, 3 – overweight, and 4 – obese). The final study sample had 48,814 respondents.

Figures 1 to 4 below show the distribution of BMI across age, gender, income, education, and visible-minority status in the sample population.

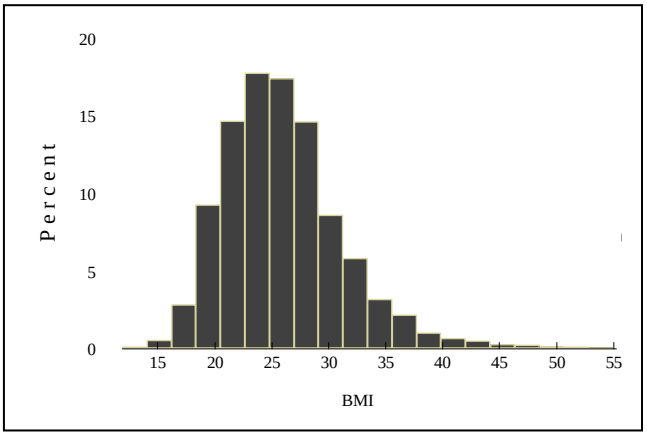

Figure 1 Frequency of self-reported BMI

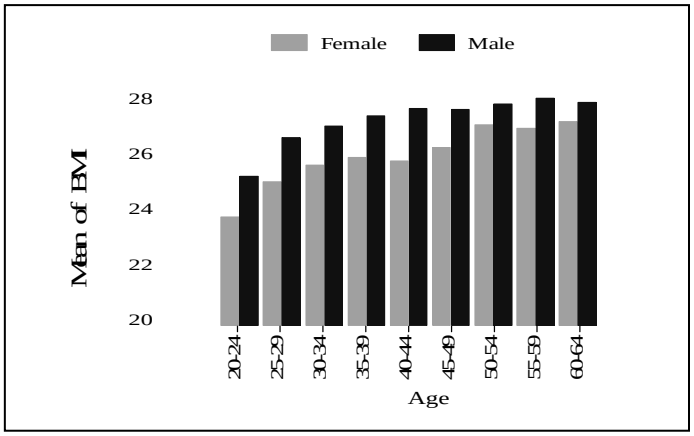

Figure 2 BMI by age group and gender

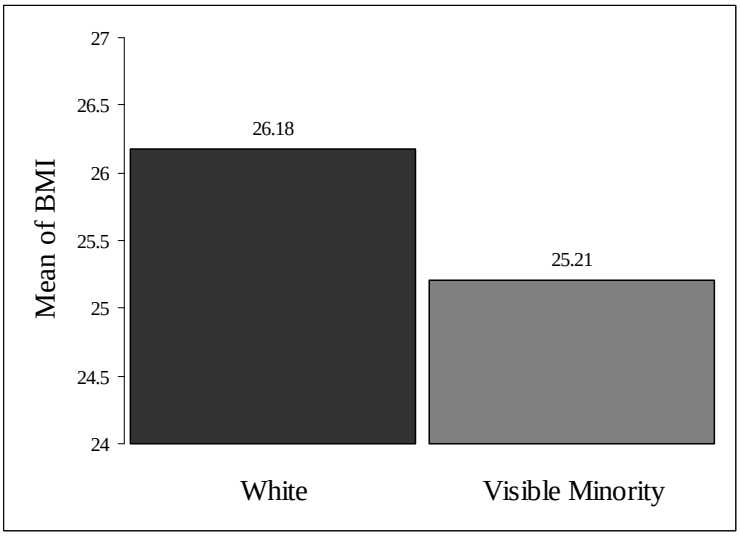

Figure 3 Means of BMI by visible-minority status

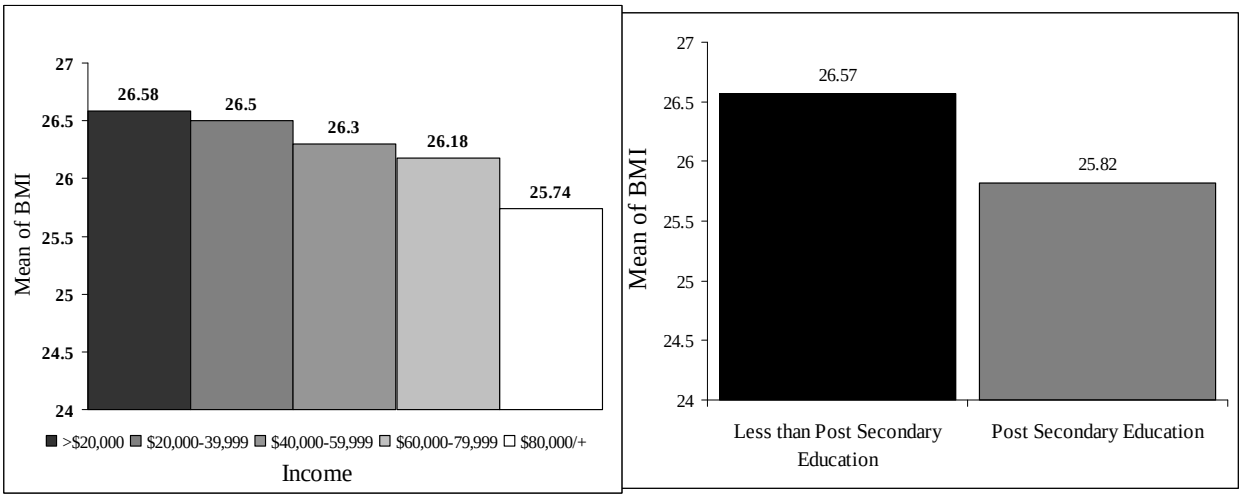

Figure 4 Means of BMI by income and education levels

In summary, these figures show that (1) the mean BMI of the sample population, 26, falls within the overweight cut-off values, 25.00–29.99, as does the median, 26 (see Figure 1 above and Table 1 below); (2) BMI generally increases with age, whereas males tend to have higher BMI than females in the same age groups (see Figure 2); (3) on average, visible minorities tend

to have lower BMI compared to the white population (see Figure 3); and (4) BMI tends to fall as education and income levels rise (see Figure 4).

4.4 Description of the independent variables

This section introduces and describes the independent variables to be used in estimation equation (1) including the subjective-wellbeing measures (life satisfaction and cognitive health status), demographic and social-economic characteristics (age, gender, marital status, income, education, and visible-minority status), peer-group indicators, and unobservable provincial fixed characteristics.

4.4.1 Subjective-wellbeing variables:

Subjective-wellbeing variables are the main independent variables of interest in this study because the wellbeing theories suggest that subjective wellbeing affects health behaviour and thus may have an impact on health outcomes like obesity. As discussed in chapter two, life satisfaction and happiness are well-established measures of subjective wellbeing, and are found in many national and international studies. These variables are discussed in detail below. In addition, as assessment of wellbeing involves cognitive judgment of life aspects by the respondents, cognitive health status is also introduced and included in the estimation equation.

1) *Life Satisfaction*

Life satisfaction is a variable derived from a question about how the respondents feel about life as a whole at the time when the CCHS survey was conducted: “How do you feel about life right now?” Life satisfaction is measured in a scale of 0 to 10, where 0 means “very dissatisfied” and 10 means “very satisfied.” Life satisfaction represents

subjective wellbeing because, first, individuals feel satisfied in their life when they see that they loved, cared for, and respected in the society, and they have the freedom of choosing activities they are interested in or the activities that match their competence level. These are the feelings that represent autonomy, competence, and relatedness concepts of the Self-determination Theory. Second, satisfaction with life increases when these psychological needs are met. Satisfied individuals engage and immerse in activities they choose to perform, accomplish them, feel positive, and have a sense of meaning and purpose, which means whatever they do, they do it for their own sake and for the greater interest of the community. These are actions that represent the PERMA concept of the Wellbeing Theory. As autonomy, competence and relatedness provide satisfaction in life and satisfied individuals nourish the five psychological strengths abbreviated in the acronym PERMA, life satisfaction, when self-reported by individuals, represents subjective wellbeing.

An alternative measure of subjective wellbeing is *emotional health* in the dataset, derived from the question "Would you describe yourself as being usually happy and interested in life, somewhat happy, somewhat unhappy, unhappy with little interest in life, so unhappy that life is not worthwhile?" at the time of the survey. Emotional health is measured using a scale of 1 to 5.

Among the two measurements of subjective wellbeing above, the life satisfaction variable was more frequently and widely used than emotional health in the last decade because (1) assessment of life satisfaction is more stable and does not vary much over the long term as the assessment involves cognitive reasoning and the use of memory; in contrast, the evaluation of emotional health is short-lived, and fades quickly depending

on the current mood of the respondent (Diener 1994, 107; Kahneman and Krueger 2006, 14); (2) the life satisfaction variable is politically relevant, empirically robust, appealing to policy makers, and prevalent in national and international surveys (Angner 2011, 26; Dolan, Layard, and Metcalfe 2011; Fleche, Smith, and Sorsa 2011; Helliwell 2008; Helliwell 2011). Therefore, life satisfaction is chosen as the main indicator of the subjective wellbeing of an individual.

The mean life satisfaction in the sample population of this study is 8 on a 0–10 point scale (see Figure 5 and Table 1 below). The sample data also shows that (1) on average, women are more satisfied with life than men; (2) there is no difference in life satisfaction across age groups; (3) white populations are more satisfied in life than visible minorities; (4) the married are more satisfied than the single, widowed, and separated; and (5) life satisfaction rises with income, while it does not show apparent pattern across education levels.

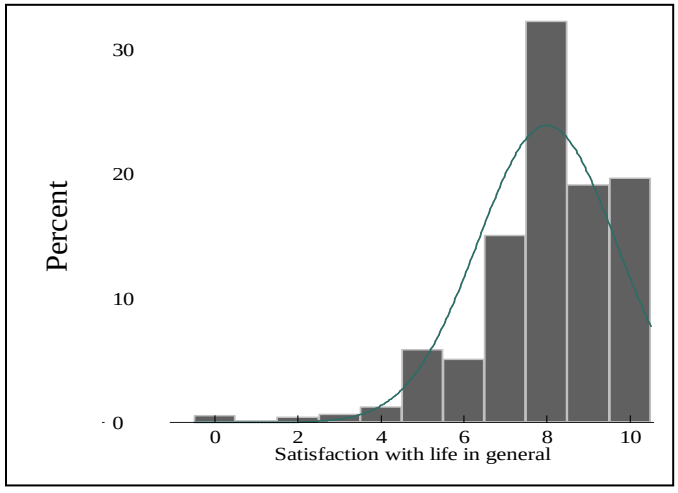

Figure 5 Distribution (frequency) of life satisfaction

The scatter plot in Figure 6 below shows that life satisfaction has a negative association with BMI, which is consistent with the prediction of the Self-determination Theory and Wellbeing Theory. In the estimation results, I expected to see a negative sign for the coefficient of life satisfaction.

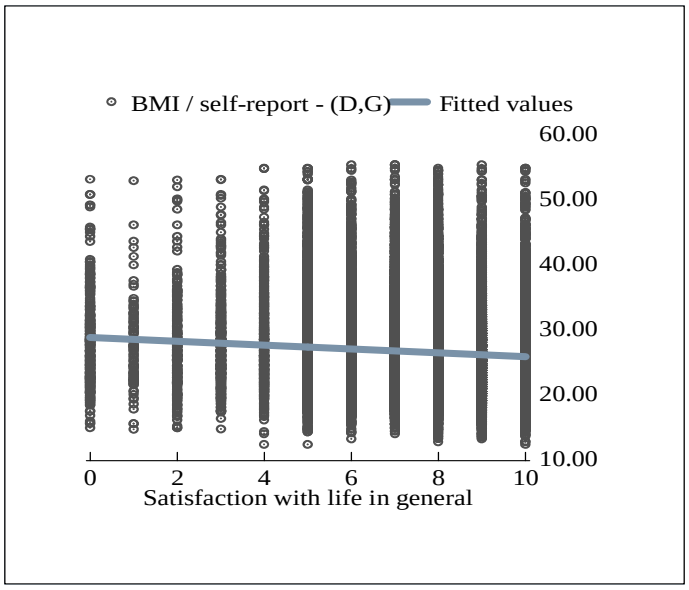

Figure 6 Scatter plot of BMI against life satisfaction

2) Cognitive Health

Cognitive health was the other measure of subjective wellbeing used in this study. This variable was derived from two questions: “how would you describe your usual ability to remember things; and how would you describe your usual ability to think and solve day-to-day problems?”, and was measured on a 1–6 scale. Cognitive health status was chosen because the concepts of Self-determination Theory and Wellbeing Theory suggest that cognitive reasoning is required for evaluation of psychological needs (autonomy, competence, relatedness) before internalizing social norms, and engaging in

socially desired activities (Dolan, Layard, and Metcalfe 2011; Michaelson el al. 2009), and such information was not directly covered by the responses to the life satisfaction questions.

The concepts of Self-determination Theory and Wellbeing Theory suggested a negative association between cognitive health and BMI. However, the scatter plot in Figure 7 below showed no clear positive or negative relationship between cognitive health and BMI. Therefore, it was not clear what signs the coefficient would show in the estimation results.

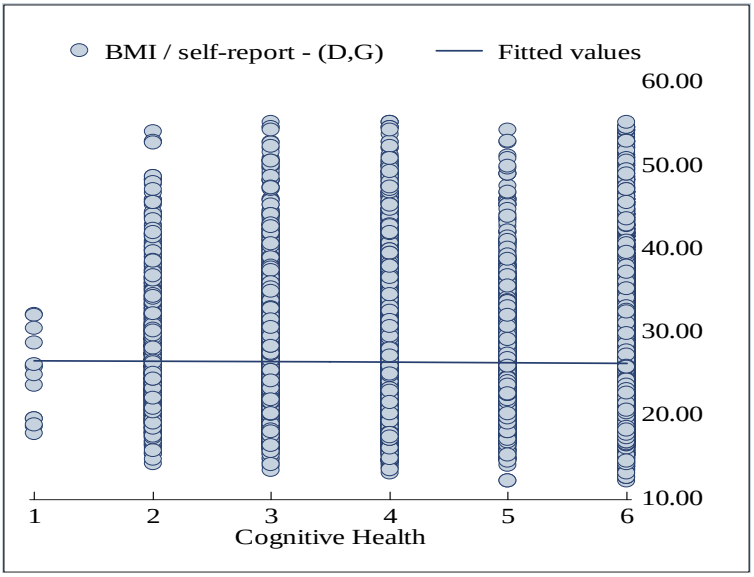

Figure 7 Scatter plot of BMI against cognitive health

In the CCHS dataset, there were also data on the other concepts of wellbeing theories including, for example, self-esteem, social support, participation, and trust. However, this information was more or less covered by the life satisfaction variable because overall assessment of different aspects of life involves these components. Since a few provinces

opted to ask these specific wellbeing questions during the survey, the data for these variables were not as complete as life satisfaction and cognitive health either. For these reasons, these indicators were not included in the main regressions.

4.4.2 Demographic and socio-economic variables

Demographic and socio-economic variables such as age, gender, marital status, visible-minority status, income, and education were included in the estimation because these variables affect BMI, as suggested by the previous empirical findings summarized in chapter two.

It is worthwhile to mention that the visible minority group in the sample population consists of population other than White people including Aboriginal population (North American Indian, Métis, Inuit), and the other cultural origins such as Chinese, Japanese, Korean, Arab, Pilipino, Black, Latin American, South Asian (e.g., East Indian, Pakistani, Sri Lankan), West Asian (e.g., Afghan, Iranian), and South east Asian (e.g., Cambodian, Indonesian, Laotian, Vietnamese).[2] It is also important to make a note here that the actual values of age and income of the respondents were not available in the CCHS database. Instead, they were grouped into several equal-sized categories. For example, the CCHS categorized respondents into nine groups at equal distance by age for the purpose of BMI calculation. For instance, age group 4 has a age range between 20 and 24 years, groups 5 has age range between 25 and 29 years, and so on. Similarly income is also grouped at equal distance, for example group 1 has respondents with no income or less than $20,000, group 2 with income from $20,000 to $39,999, group 3 with income from $40,000 to $59,999, and so on (See table A1 in the Appendix for further detail). How these variables were constructed is described in detail in Table A1 in the Appendix and the

[2] For details about composition of the visible minorities, see: CCHS, Annual Component - 2010 Questionnaire, p. 331-332, http://search1.odesi.ca/documentation/CCHS_2010/2009-2010/doc/cchs-escc2010que-eng.pdf, Accessed: 31 July 2013; and CCHS Annual Component, 2010, derived Variable Specifications, p. 158-159, http://datalib.usask.ca.cyber.usask.ca/dli/health/cchs/2010/doc/cchs-escc2010derived-var-eng.pdf, Accessed: 31 July 2013

summary statistics of these variables and the other dependent and independent variables are provided in Table 1 below.

As the summarized obesity literature suggested, older people, men, married people, people with less income, people with less education, and visible-minority groups are expected to have lower BMI than their respective counterparts.

4.4.3 Peer group indicators

The obesity literature and the Social Cognitive Theory suggest that people living in particular neighbourhoods or with similar socioeconomic status and culture behave similarly. In other words, people's behaviours are influenced by their peer groups.

CCHS classified a total of 117 health regions from all the provinces into nine peer groups (e.g., A, B, C, D, E, F, G, H, and I). The health regions in each peer group are similar in the following four dimensions: (1) rural–urban geographical setting, (2) percentage of Aboriginal population, (3) percentage of immigrant population, and (4) employment rate relative to the national average.[3]

Peer group dummies were included in the estimation model because respondents' health behaviours are affected by "who they belong to" and "where they live," i.e., the characteristics of the social and physical environment of individuals—one of the relationships explained by the environmental determinants of behaviour and observational learning concepts of the Social Cognitive Theory. The reference group of the peer group dummies is peer group A, which is characterized as a mix of urban–rural areas, and with average percentage of Aboriginal and immigrant populations in the total population, and above average employment rate. The health

[3] Table A2 of the Appendix shows how health regions are classified into peer groups, and the percentage of sample population in each peer group. For more details, see:
http://www.statcan.gc.ca/pub/82-221-x/2011002/regions/hrpg2007-eng.htm. 28 July, 2011; Canadian Community Health Survey (CCHS), Annual component user guide 2010, and 2009–2010 micro data files. June 2011. p. 72–75.

regions belonging to the reference peer group include, for example, La Capitale-Nationale (Quebec), Regina and Saskatoon (Saskatchewan), Fraser East (British Columbia), and Winnipeg (Manitoba).

Peer group dummies thus capture community-level influence on obesity. Based on the literature summarized in Chapter 2, we expected to see higher obesity rate in the peer groups that had higher concentrations of Aboriginal populations (peer group E, F, and H). Since people living in rural areas have fewer amenities and may feel that they are environmentally challenged to have access to fresh food or to remaining active physically, peer groups that were comprised of northern, remote, and rural health regions (peer group D, E, F, and H) were also expected to have higher BMI than the reference group.

4.4.4 Provincial fixed effect

In addition to individual and community-level factors, provincial dummy variables were included to capture the unobserved unique characteristics of provinces that affect people's health behaviours including, for example, climate, weather, and provincial policies.

The summary statistics of the dependent and independent variables discussed above are provided in Table 1 below.

Table 1 Summary statistics of variables

Variable	Observation	Mean	Std. Dev.	Min	Max	Median
Dependent variables:						
BMI	48814	26	5.4	12	55	26
Obesity (1, if BMI >/= 30 kg/m^2); 0, otherwise	48814	.2	.4	0	1	0
Life satisfaction in general	48814	8	1.7	0	10	8
Cognitive health	48814	5.4	1.1	1	6	6
Age (grouped)	48814	9.1	4.1	1	16	10

Variable	Observation	Mean	Std. Dev.	Min	Max	Median
Male	48814	.47	.5	0	1	0
Married	48814	.43	.49	0	1	0
Visible Minority	48814	.13	.34	0	1	0
Income (grouped)	48814	3.4	1.4	1	5	3
Education	48814	.72	.45	0	1	1
Peer group dummies						
Peer Group A—the reference group; (urban–rural mix with average Aboriginal and immigrant population)	48814	.25	.43	0	1	0
Peer Group B (urban population with low Aboriginal population)	48814	.18	.38	0	1	0
Peer Group C (rural-urban mix, low Immigrant population)	48814	.16	.37	0	1	0
Peer Group D (rural, high employment)	48814	.051	.22	0	1	0
Peer Group E (remote rural with high Aboriginal population)	48814	.18	.38	0	1	0
Peer Group F (northern remote with very high Aboriginal, low employment)	48814	.0079	.089	0	1	0
Peer Group G (largest metro with very low Aboriginal and high immigrant population)	48814	.063	.24	0	1	0
Peer Group H (northern rural with high Aboriginal population)	48814	.063	.24	0	1	0
Peer Group I (rural eastern with low employment)	48814	.05	.22	0	1	0
Provincial dummies						
Quebec—the reference province	48814	.19	.39	0	1	0
New Brunswick	48814	.04	.2	0	1	0
Saskatchewan	48814	.057	.23	0	1	0
British Columbia	48814	.12	.32	0	1	0
Nova Scotia	48814	.039	.19	0	1	0
Ontario	48814	.33	.47	0	1	0
Manitoba	48814	.055	.23	0	1	0
Alberta	48814	.095	.29	0	1	0
Yukon and NWT	48814	.031	.17	0	1	0
Instrumental variables to be introduced later						
Sunny Weather	2411	3.1	1.6	1	5	3
Availability of Social Support	2411	7.6	7.2	0	90	5

Variable	Observation	Mean	Std. Dev.	Min	Max	Median
Availability of Transportation Facility	2411	2	.05	1	2	2

If we check the correlation matrix in Table 2 below, we see that there is no apparent problem of multi-collinearity (correlation more than 0.80) between the independent variables.

Table 2 Correlation table

Observation = 48,814	BMI	Life satisfaction	Cognitive health	Age	Male	Married	Visible minority	Income	Education
BMI	1.00								
Life satisfaction	-0.10	1.00							
Cognitive health	-0.02	0.21	1.00						
Age	0.21	-0.07	0.00	1.00					
Male	0.08	-0.02	0.01	-0.06	1.00				
Married	0.12	0.12	0.05	0.24	0.04	1.00			
Visible Minority	-0.06	-0.03	-0.03	-0.17	0.01	-0.01	1.00		
Income	-0.06	0.20	0.12	-0.31	0.11	0.26	-0.04	1.00	
Education	-0.06	0.10	0.09	-0.24	0.08	0.12	0.02	0.39	1.00
Peer Group A	-0.01	-0.01	0.00	0.02	0.00	-0.01	-0.07	0.00	0.01
Peer Group B	-0.05	-0.01	0.01	-0.05	-0.00	0.03	0.12	0.12	0.06
Peer Group C	0.02	0.02	0.01	0.04	-0.01	-0.02	-0.09	-0.09	-0.02
Peer Group D	0.02	0.02	-0.01	0.01	0.01	0.02	-0.05	-0.01	-0.03
Peer Group E	0.03	0.01	-0.01	0.01	0.01	0.03	-0.07	0.02	-0.02
Peer Group F	0.01	0.00	-0.02	-0.00	0.00	0.00	0.05	-0.00	-0.01
Peer Group G	-0.05	-0.04	0.02	-0.02	-0.00	-0.04	0.15	-0.03	0.03
Peer Group H	0.02	0.00	-0.01	-0.05	0.01	-0.04	0.09	0.03	-0.02
Peer Group I	0.03	0.02	-0.01	0.03	-0.01	0.01	-0.04	-0.08	-0.04
	Peer Group-A	Peer Group-B	Peer Group-C	Peer Group-D	Peer Group-E	Peer Group-F	Peer Group-G	Peer Group-H	Peer Group-I
Peer Group A	1.00								
Peer Group B	-0.27	1.00							
Peer Group C	-0.25	-0.20	1.00						
Peer Group D	-0.13	-0.11	-0.10	1.00					
Peer Group E	-0.27	-0.22	-0.20	-0.11	1.00				
Peer Group F	-0.05	-0.04	-0.04	-0.02	-0.04	1.00			
Peer Group G	-0.15	-0.12	-0.11	-0.06	-0.12	-0.02	1.00		
Peer Group H	-0.15	-0.12	-0.11	-0.06	-0.12	-0.02	-0.07	1.00	
Peer Group I	-0.13	-0.11	-0.10	-0.05	-0.11	-0.02	-0.06	-0.06	1.00

4.5 Model specification and estimation methods

Four model specifications were used in the study. The first model started with including only subjective wellbeing measures as independent variables and then subsets of demographic and socioeconomic characteristics, peer group effects, and provincial fixed characteristics indictors were gradually added from one model to another (see Table 3 below). More specifically, model 1 tested the impact of life satisfaction and cognitive health on BMI without any control variables; model 2 included demographic and socio-economic controls; model 3 added peer group dummies to capture the impact of community-level influence, and model 4 further included provincial dummies to control for unobserved provincial fixed characteristics. The purpose of this procedure was to see whether the three subsets of gradually added variables were strongly correlated with the subjective wellbeing measures or not, and whether their omission lead to biased estimates of coefficients of subjective wellbeing measures.

Table 3 Alternative-model specifications

Independent variables	Model 1	Model 2	Model 3	Model 4
Subjective wellbeing indicators:	√	√	√	√
Life satisfaction and Cognitive health				
Demographic and socio-economic indicators:		√	√	√
Age, Male, Visible minority, Married,				
Education and Income				
Peer groups:			√	√
Peer Group dummies				
Provincial fixed characteristics:				√
Provincial dummies				

Three estimation methods were introduced and applied to these model specifications: Ordinary Least Square (OLS), Logistic (Logit), and Two-Stage Least Square (2SLS) estimation.

The three estimation methods and their corresponding estimation results are discussed in more detail in the following chapter.

Chapter 5
ESTIMATION RESULTS AND DISCUSSION

Results of three types of estimations, Ordinary Least Square (OLS), Logistic (Logit), and Instrumental Variable Two-Stage Least Square (2SLS), are presented in this chapter followed by interpretation, discussion, and comparison of results. OLS was used to gauge the magnitude of the impact of life subjective wellbeing variables on BMI. As BMI is a continuous measure of obesity and cannot directly provide an idea of the impact of subjective wellbeing measures on the probability of being obese, a Logit model was also used. OLS and Logit estimation both used the same entire sample (N = 48814) that involved all the provinces. Finally, 2SLS estimation was brought into separate the independent impact of life satisfaction on BMI from the feedback effect that might run from BMI to life satisfaction, by using three instrumental variables for life satisfaction. Since the instruments used in the 2SLS estimation were only available for the province of Quebec, the sample size (N = 2411) was significantly reduced in the 2SLS estimation.

5.1 Ordinary Least Square (OLS) Estimation Result

First, OLS estimator was used to see the impact of life satisfaction and cognitive health, and of the other covariates on BMI. Table 4 reports the OLS estimation results. The dependent variable in all the models in Table 4 was BMI.

5.1.1 The estimation result

Table 4 OLS estimation results

Dependent variable: Body Mass Index (BMI)				
Independent Variables:	Model 1	Model 2	Model 3	Model 4
Subjective wellbeing indicators				
Life satisfaction	-.327***	-.306***	-.322***	-.321***
Cognitive health	.020	-.003	.011	.041
Demographic and social-economic indicators:				
Age		.219***	.223***	.227***
Male		.868***	.855***	.867***
Married		1.041***	1.008***	.940***
Visible minority		-.536***	-.341***	-.363***
Income		-.052**	-.027	-.042*
Education		-.277***	-.217***	-.179**
Peer group dummies				
Peer Group A (urban-rural mix, average percentage of Aboriginals and immigrants in population)		Reference	Reference	Reference
Peer Group B (mainly urban; high employment; low proportion of Aboriginal and higher than average immigrant population)			-.409***	-.551***
Peer Group C (rural-urban mix, low percentage of immigrants in population)			.356***	.246**
Peer Group D (rural with high employment)			.559***	.240
Peer Group E (remote rural with high percentage of Aboriginals in population)			.374***	.221**
Peer Group F (northern remote with very high percentage of Aboriginals in population and low employment)			1.087***	.638*
Peer Group G (largest metro with very low percentage of Aboriginals and high percentage of immigrants in population)			-.870***	-.699***
Peer Group H (northern rural with high percentage of Aboriginals in population)			.726***	1.076***
Peer Group I (rural with low employment)			.586***	-.033
Provincial dummies				
Quebec				Reference

Dependent variable: Body Mass Index (BMI)				
Independent Variables:	Model 1	Model 2	Model 3	Model 4
New Brunswick (NB)				1.244***
Saskatchewan (SK)				.917***
British Columbia (BC)				-.126
Nova Scotia (NS)				.807***
Ontario				.655***
Manitoba				.869***
Alberta				1.043***
Newfoundland and Labrador (NFL)				1.582***
Prince Edward Island (PEI)				.479
Yukon, Nunavut and NWT				-.037
Constant	28.687***	26.230***	26.004***	25.403***
Number of observation	48814	48814	48814	48814
F Statistics	247.43	434.33	239.19	160.51
Adjusted R^2	.01	.07	.07	.08
	Significance levels (*p* value): * p<.05; ** p<.01; *** p<.001			

5.1.1 Interpretation:

Of the four models in Table 4 above, coefficients in model 4 is interpreted here because model 4 included all the variables to interpret, but the estimation results of the other models are also discussed. A cut-off significance level of 5 percent was used throughout the study to judge statistical significance. Results are interpreted as below.

All the models in Table 4 show a clear statistically significant negative association between life satisfaction and BMI after controlling for the various subsets of covariates. In model 4, an increase in life satisfaction by one unit (in a scale of 0 to 10) is expected to decrease BMI by 0.321 kg/m^2, all else being equal. Most importantly, the sign, magnitude, and significance of life satisfaction are robust across all models; in other words, they did not change from model to model when new variables were added, which suggests that the subset of demographic and

socioeconomic characteristics, peer groups, and provincial fixed characteristics that were gradually added were not strongly correlated with life satisfaction, and their omission would not likely lead to a biased estimate of coefficient of life satisfaction.

The impact of cognitive health, however, is not statistically significant in any of the models at five percent significance level.

The results in Table 4 also show that BMI is higher for older than younger population, for males than females, and for the married than the single, widowed, and separated, all else being equal. In addition, the BMI is generally higher for people with lower income than those with higher income, and for those without post-secondary education than those with post-secondary education. The BMI is also lower among visible minorities than white populations. These findings are generally consistent with the past empirical findings summarized in chapter two (see for example, McLaren 2009; McLaren and Godley 2009; PHAC 2011, 6, 18–21; Shields et al. 2010, 1–15; Tjepkema 2005).

In addition, the coefficients of the peer group dummies revealed that people who live in rural areas (as in peer group D, E, F, and H), particularly in those with low employment rates and higher concentrations of Aboriginal populations (as in peer groups E, F, and H) are expected to have higher average BMI than the reference peer group (peer group A), all else being equal. (See Table A2 for further details and the name of the health regions). Conversely, people living in urban or metro centers with very low percentage of Aboriginals and high percentage of immigrants in population (peer group B and G) are expected to have lower average BMI than the reference peer group, all else being equal. These findings support the Social Cognitive Theory. Peer group, as in the way they were classified, captures the difference across communities with regard to social norms concerning health behaviour, as well as some geographic characteristics

(urban–rural setting). The significance of the peer group dummies suggests that in addition to the effects of individual level factors, peer groups also affect obesity.

By looking at provincial dummy variables in model 4, we see that respondents in all provinces except British Columbia, Prince Edward Island, and Yukon/ Nunavut/ Northwest Territories have statistically significant higher average BMI than those in Quebec (the province of reference), while the BMI in the other provinces and territories are not statistically different from that of Quebec. The differences in average BMI across provinces and territories may be attributed to unobserved characteristic specific to those provinces. For example, Dutton and McLaren (2011) have noted that people in the Atlantic provinces (Nova Scotia, New Brunswick, Prince Edward Island, and Newfoundland) consume less fresh fruit and vegetable than other provinces because of the unfavourable climate to grow fresh fruit and vegetables, and the greater distance to transport perishable fruits and vegetables in these provinces. Moreover, differences in policy environments may also play a role in provincial difference in obesity rate. For example, higher BMI in Atlantic Provinces may also be attributed to psychological stress from higher rates of unemployment (Helliwell, Layard, and Sachs 2012).[4]

5.1.2 Discussion:

The main message drawn from the OLS estimation results in Table 4 is that life satisfaction has a significant, robust, and negative association with BMI. In addition, the magnitude of the impact of life satisfaction is quite substantial compared with that of other variables like education and income. In model 4, one unit of annual total income increase in a scale of 1 to 5 (equivalent to an increase of $20,000) is expected to reduce BMI by 0.042 kg/m^2,

[4] For provincial variation in unemployment, see Canada Labour Force Survey, June, 2013 at: http://www.statcan.gc.ca/daily-quotidien/130705/dq130705a-eng.htm.

while one unit of life satisfaction increase in a scale of 0 to 10 is expected to reduce BMI by 0.321 kg/m^2. This means, the effect of one unit increase in life satisfaction on BMI is equivalent to the effect of $150,000 increase in annual total income for an individual, all else being equal. Similarly, the effect of one unit increase in life satisfaction on BMI is equivalent to 1.79 times of the effect of having post secondary education for an individual, all else being equal.

As Canadians are already happy (sample mean is 8 in a scale of 0 to 10, see Table 1), it appears there is little room for policies to manipulate life satisfaction of individuals and reduce their average BMI. For example, an increase in the average life satisfaction of Canadians from 8 to 10 would reduce their average BMI by 0.624 kg/m^2. Such a change cannot bring the overweight average Canadians (sample mean BMI of 26 kg/m^2) to the normal weight category (BMI between 18.50 $kg.m^2$ and 24.99 kg/m^2).

While findings of this study suggest that life satisfaction affects obesity, the small marginal effect of life satisfaction on BMI as discussed above cannot substantiate arguments for using it as a direction for future major public health intervention. However, as Canadian families are increasingly giving up leisure time and cultural activities with family and friends in spite of rising income and education level (Statistics Canada 2012b, 2013; Canadian Index of Wellbeing Network 2012, 15) this may have, as the subjective wellbeing literature suggests, an effect on many socio economic outcomes including health behaviours and health outcome.

This is particularly true for the 29 percent of the population whose life satisfaction falls below the mean (see Figure 5). Table 5 shows that this segment of the population has a mean life satisfaction of 6, below the average of 8, and also a mean BMI of 26.8, higher than the BMI of the other groups. Most of the population lives in remote or rural regions, particularly with high

concentration of Aboriginal populations and low employment opportunities (peer group D, E, F and H).

Table 5 Mean BMI and life satisfaction of the population whose life satisfaction falls below vs. above mean life satisfaction

	Mean BMI	Mean Life Satisfaction
29% of Population who have below average life satisfaction	26.77	6
71% of Population who have above average life satisfaction	25.72	9
Total	26.03	8

Considering rising obesity prevalence among Canadians and its cost to the economy, there is imperative for reducing the obesity rate in this group of citizens. In addition to policies that increase income and improve education of this population, policies focusing on improving subjective wellbeing would also be useful to some extent. For example, if the average life satisfaction of this group (6) could be raised to the current average of all Canadians (8), it would reduce their average BMI by 0.64 kg/m^2. This move would not bring their average BMI from the overweight category to the normal weight range, but it does help reduce obesity.

While increasing the life satisfaction of the group with the lowest life satisfaction can have some effect, increasing life satisfaction may be costly. Since the subjective wellbeing theory is still new, policy makers may not know how to increase life satisfaction in an effective way. In sum, the OLS regression results suggest that BMI could be improved by increasing income, improving education, increasing subjective wellbeing, and encouraging peer effect. The way to tackle obesity is to work on a number of different fronts at the same time.

R^2 statistics in model 4 show that our model explains only eight percent of variations in BMI. This suggests that there are other unknown factors that may be responsible for the rest of

the variation; including for example, individual fixed effect—characteristics that do not change over time such as, race, personality trait (introvert, extrovert, etc), family background, and genetic makeup. Individual fixed effect can be controlled only when longitude data becomes available. These sources of variation are left for future research when there are more complete and richer data.

5.2 Logistic regression

Since the dependent variable BMI in the OLS models above is a continuous measure, it cannot directly represent the likelihood of being obese.

Obesity is defined against a cut-off level of BMI. A cut-off level of BMI is policy relevant in the sense that a person having BMI of 30 kg/m^2 or more is considered obese and carries higher risks of having chronic diseases and incurs greater health care cost than those with a lower BMI (Bodkin, Ding, and Scale 2009). Therefore, although it is technically possible to calculate the probability of being obese based on the OLS estimation results, the categorization and distribution of obesity by cut-off level above itself is an important policy parameter and it is important to directly investigate the effect of life satisfaction on the probability of being obese. For this reason, instead of using a continuous BMI variable, many empirical works prefer to use a dummy variable for obesity as the dependent variable. This type of dichotomous dependent variable requires Logit estimation.

The dependent variable in the Logit model below is labeled as *Obesity*, which is a binary variable generated from BMI values of the respondents. People with a BMI of 30 kg/m^2 or above are obese (*Obesity*=1) while those with BMI less than 30 kg/m^2 are not obese (*Obesity*=0). Twenty-two percent of the respondents were found to be obese (see the summary statistics in

Table 1). The independent variables in the following Logit estimations were the same as in OLS models. Results of four Logit models are provided in Table 6 below.

It should be noted that the coefficients reported in Table 6 are marginal effects. Marginal effects represent the changes in probability of being obese with respect to changes in the independent variables of interest. For continuous independent variables, marginal effects were computed by setting the values of all these independent variables at their means, and then seeing how the change in one of the continuous independent variables affects the probability of being obese, all else being held constant. The marginal effects for dummy variables show the changes in the probability of being obese as a dummy independent variable changes from 0 to 1, all other independent variables being held constant at the means.

Table 6 Logistic regression result

(Coefficients represent marginal effects)

Dependent Variable: Obesity (0/1)	Models			
Independent variables	(1)	(2)	(3)	(4)
Subjective Wellbeing indicators:				
Life satisfaction	-.019***	-.018***	-.019***	-.019***
Cognitive health	-.002	-.001	-.001	.001
Demographic and social-economic indicators:				
Age		.005***	.005***	.006***
Male		.015***	.015***	. .015***
Married		.051***	.049***	.044***
Visible minority		-.033***	-.023***	-.024***
Income		-.008***	-.006***	-.007***
Education		-.021***	-.018***	-.016***
Peer groups:				
Peer Group A (urban-rural mix, average percentage of Aboriginals and immigrants in population)			Reference	Reference
Peer Group B (mainly urban; high employment; low proportion of Aboriginal and higher than			-.025***	-.034***

Dependent Variable: Obesity (0/1)	Models			
	(1)	(2)	(3)	(4)
Independent variables				
average immigrant population)				
Peer Group C (rural-urban mix, low percentage of immigrants in population)			.026***	.018*
Peer Group D (rural with high employment)			.030**	.012
Peer Group E (remote rural with high percentage of Aboriginals in population)			.024***	.013*
Peer Group F (northern remote with very high percentage of Aboriginals in population and low employment)			.071**	.033
Peer Group G (largest metro with very low percentage of Aboriginals and high percentage of immigrants in population)			-.041***	-.032***
Peer Group H (northern rural with high percentage of Aboriginals in population)			.033***	.061***
Peer Group I (rural with low employment)			.036***	-.005
Provincial fixed characteristics				
Quebec				Reference
New Brunswick (NB)				.100***
Saskatchewan (SK)				.072***
British Columbia (BC)				.005
Nova Scotia (NS)				.051***
Ontario				. .048***
Manitoba				.058***
Alberta				.074***
Newfoundland and Labrador (NFL)				.116***
Prince Edward Island (PEI)				.020
Yukon, North-West Territories & Nunavut				-.003
Constant	-.388***	-.657***	-.751***	-1.02***
N	48814	48814	48814	48814
LR chi^2	345.32	931.85	1104.61	1335.12

Significance level (*p* value): * p<.05; ** p<.01; *** p<.001

Of the four models in Table 6, model 4 is chosen for interpretation, because it is the most complete model and it outperformed the other models in explaining the probability of being

obese in terms of LR Chi^2 value. We see that the overall performance (Chi^2) increases substantially from one model to another as we gradually add variables from one model to another. Moreover, the marginal effect of life satisfaction is robust. In other words, it did not change greatly across the models.

In general, the Logistic regression results in Table 6 are consistent with the OLS results in Table 4 in terms of significance level and signs of coefficients of all the independent variables. Life satisfaction is statically significant at less than 0.1 percent level. In particular, at sample means, one unit increase in life satisfaction in a scale of 1 to 10 is expected to decrease the likelihood of being obese by 0.019 or almost two percentage points, all else being equal. As in the OLS models, cognitive health in the Logistic models is not statistically significant. Similarly, the likelihood of being obese is expected to increase as age increases, is higher in males than females, and is higher for the married than those unmarried, but is lower in visible minority groups than in white people. This likelihood of being obese is also expected to decrease as income and education increases. The results for peer groups are the same as in OLS models, i.e., the likelihood of being obese is greater in rural areas, particularly those with a significant Aboriginal population, compared to the reference group which consists of an urban–rural mixed setting with an average percentage of Aboriginal and immigrant populations. The findings with provincial dummies are same with those in OLS results.

5.3 Instrumental Variable Two-stage least square (2SLS) estimation

The findings from OLS and Logit estimates revealed that life satisfaction had a negative and robust relationship with the level of BMI or the likelihood of being obese, even after

controlling for the demographics, socioeconomic factors, peer groups, and unobserved provincial fixed characteristics. However, we were not sure about the direction of causality between life satisfaction and obesity measures. The literature discussed earlier suggests that there is a possibility of two-way causality, i.e., BMI or probability of being obese may also have feedback effect on life satisfaction. If feedback effects are running, it is possible that part of the life satisfaction variable is endogenous, i.e., life satisfaction is correlated with random shocks in error term, which also affects BMI. In other words, life satisfaction becomes a function of BMI through the error term. In this situation, the parameter estimate of life satisfaction in the OLS or Logit equation becomes inconsistent and biased.

The problem of bidirectional causality, or in other words endogeniety, is often solved using two-stage least square estimation (2SLS) where instrumental variables are used to separate the direct impact of the suspect endogenous independent variable (here life satisfaction) from the feedback effect of the dependent variable. The ideal instruments are correlated with life satisfaction, but are uncorrelated with BMI. Such ideal instruments are often variables that refer to the external context of individuals and that affect the community at large, including, for example, weather, crime, population growth, quality of governance, and stability.

5.3.1 Selection of instrument variables

From the CCHS dataset, three instruments were selected: sunny weather, availability of social support, and availability of transportation facilities. The instrument “sunny weather” is represented by the variable “frequency of sunscreen use on the face” in the CCHS. This variable indicates how often sunshine in a particular area compels respondents to use sunscreen on their faces. Sunny weather is part of the default climate, on which the individual respondent has no control, but that directly affects life satisfaction and happiness of all respondents in a particular

geographical area. On the other hand, sunny weather has no apparent strong impact on BMI. Whether weather affects BMI is often a question of whether the person perceives it as a barrier to remaining active. A study has found that only 18 percent of the inactive population and 33 percent of active population think that weather would probably increase their physical activities (Dishman, Sallis, and Orenstein 1985). In our sample data, according to the responses to the question "whether weather is stopping you from improving health?" only two percent of the respondents answered that they perceive weather as a barrier to improving- health.

The instrument "availability of social support" is represented by the variable "number of close friends and relatives" in the CCHS. This variable is constructed by a question about how many close friends and close relatives the respondent has, i.e., people the respondent feels at ease with and can talk to about what is on his or her mind. The instrument "availability of transportation facility" is represented by a dichotomous variable about whether the respondent has not had the H1N1 flu shot due to transportation problems (see Table A1 in the appendix). Similar to sunny weather, these two additional instruments availability of social support and availability of transportation are likely to affect individuals' life satisfaction in general more than obesity (Helliwell 2008).

Whether these three instruments can isolate and remove the endogenous part of life satisfaction and keep the exogenous part in explaining BMI finally depends on the test results on their relevance and validity. In this regard, the instruments must satisfy two conditions: first, they must be relevant—they must correlate with life satisfaction; and second, they must be valid or exogenous—they must not correlate with BMI or error term.

Whether the instruments are relevant can be tested by checking their joint statistical significance after the first stage regression of two-stage least square (2SLS) estimation. To be

considered as relevant, these instruments are required to have a joint F statistics that is more than 10 (Staiger and Stock 1997) and the coefficients of these instruments have to be sensible in direction. If these conditions are met, we can say that the instruments are strongly correlated with life satisfaction, and are relevant.

The validity of instruments can be tested by the Sargan and Basmann over-identification test. As we have three instruments for one endogenous variable, we can effectively test whether some of them are uncorrelated with BMI. The over-identification test estimates the BMI equation with one instrument first, and calculates the residual. Then, it tests whether this residual and the second instrument are correlated. If they are not, it can be said that the second instrument is uncorrelated with BMI. This process goes on until the last instrument. In summary, the over-identification test assumes that at least one instrument is valid or uncorrelated with BMI. This is why at least one more instrument than the number of endogenous variables is required to establish validity of the instruments. If the Sargan and Basmann over-identification test statistic (Chi^2 score) does not exceed the critical value or shows a *p*-value higher than the cut-off value of 0.05, the null hypothesis that the instruments are uncorrelated with BMI or the error term cannot be rejected, and that means, the instruments are exogenous. As they are exogenous, it can be said that they are valid, and can isolate the exogenous and independent part of life satisfaction variable in explaining BMI.

Whether life satisfaction is endogenous in the OLS regression can also be tested by the Hausman test (1978). The idea of the Hausman test is to see if the estimates from OLS and two-stage least square methods (2SLS) are different. In the test, if the Wu-Hausman F score is statistically different from zero, we can reject the null hypothesis that life satisfaction is not correlated with BMI or error term, and life satisfaction is truly endogenous.

It should be noted that substantial efforts were taken to find useful instruments. The three variables discussed above were the best I could find so far with regard to their relevance and validity as instruments. However, since the data of the three instrumental variables were collected for Quebec only in the CCHS, the sample size for the 2SLS estimation described below was substantially reduced to 2411. I could not find data of other better subset of instrument that provide a larger sample size.

5.3.2 The two stages in the 2SLS estimation

The possible endogeneity problem with life satisfaction was addressed by the two-stage least square (2SLS) estimation method in two stages. In the first stage, life satisfaction was explained by the instruments and the other covariates; in the second stage, BMI was explained by the predicted value of life satisfaction obtained from the first-stage estimation result and the other independent variables.

Stage 1 explained life satisfaction as a function of the three instrumental variables, and all the other covariates included in model 4 of the OLS and logistic regressions. In this stage, instruments predicted the exogenous part of life satisfaction that was uncorrelated with BMI or error term. The estimation equation used in the first stage was

$$\begin{aligned} \textit{Life Satisfaction} = \alpha + \gamma_1 * \textit{Instruments (sunny weather, availability of social support,} \\ \textit{availability of transportation facilities)} + \gamma_2 * \textit{Demographic and Socio-} \\ \textit{economic Variables} + \gamma_3 * \textit{Peer Groups} + \gamma_4 * \textit{Provincial Dummies} + \upsilon \end{aligned} \qquad (2)$$

A set of predicted values of life satisfaction are obtained based on the estimation result of equation (2). These predicted values were supposed to contain only the exogenous part of life satisfaction that was independent of BMI because the instruments isolated and removed the

endogenous part from it, under the condition that the instruments as a group pass both the relevance and validity tests of instruments.

Stage 2 explained BMI as a function of the predicted life satisfaction and all other independent variables through estimation equation (3) below:

$$BMI = \alpha + \beta 1 * Predicted\ life\ satisfaction + \beta_2 * Demographic\ and\ Socio\text{-}economic\ variables + \beta_3 * Peer\ Groups + \beta_4 * Provincial\ Dummies + \varepsilon \quad (3)$$

Thus in the second stage, not all of the variations in life satisfaction (endogenous and exogenous portion) were used to explain BMI—only the predicted exogenous portion of it that was explained by the instruments and the other covariates in the first stage was used. In this way, the endogeneity or feedback effect in the model was removed, and this two-stage procedure can be used to answer the question "whether life satisfaction has independent impact on BMI".

5.3.3 Estimation result of the first stage of the 2SLS estimation

The estimation result of the first stage of the 2SLS estimates is presented in Table 9 below. The test statistics for the relevance and validity tests of the three instruments are provided in Table 9.

Tables 7 and 8 show that the three used instruments—sunny weather, availability of social support, and availability of transportation facilities—were relevant and can be used to explain life satisfaction, because the joint F statistics for the first-stage estimation is more than 10, the coefficients for the three instruments are individually statistically significant and sensible in direction, and the joint effect of the three instruments are significantly different from zero with a *p*-value of less than 1 percent.

The three used instruments were found to be reasonably valid, too, because the Chi^2 score for the Sargan and Basmann over-identification test is with a *p*-value more than the cut-off value of 5 percent, suggesting that the null hypothesis that the instruments are uncorrelated with BMI or the error term cannot be rejected. This test result indicates that the instruments were exogenous to BMI and there was no feedback effect running from BMI to the instruments.

Whether life satisfaction was truly endogenous in estimation equation (1) was tested, too. The statistically significant F statistics for the Wu-Hausman test rejected the null hypothesis that life satisfaction was not endogenous (see Table 9). This indicates that life satisfaction was truly endogenous to BMI and the 2SLS estimation was needed to separate out the exogenous part of life satisfaction.

Table 7 First stage estimate result of the 2SLS regression

Life Satisfaction (Dependent Variable)	Coefficient.
Instruments:	
(1) Sunny Weather	**.071*** **
(2) Availability of Social Support	**.014*** **
(3) Availability of Transportation Facility	**1.148** **
Other Variables:	
Cognitive Health	.288***
Age	-.013
Male	-.080
Married	.201**
Visible Minority	-.080
Income	.158***
Education	-.126
Peer Group A (urban-rural mix, average percentage of Aboriginals and immigrants in population)	Reference
Peer Group B (mainly urban; high employment; low proportion of Aboriginal and higher than average immigrant population)	(omitted)
Peer Group C (rural-urban mix, low percentage of immigrants in population)	.131
Peer Group D (rural with high employment)	(omitted)
Peer Group E (remote rural with high percentage of Aboriginals in population)	.080

Life Satisfaction (Dependent Variable)	Coefficient.
Peer Group F (northern remote with very high percentage of Aboriginals in Population and low employment)	(omitted)
Peer Group G (largest metro with very low percentage of Aboriginals and high Percentage of immigrants in population)	-.106
Peer Group H (northern rural with high percentage of Aboriginals in population)	.329**
Peer Group I (rural with low employment)	.351**
Constant	3.514***
Number of observations	2411
F statistics of the model	14.33
Adjusted R^2	.10
Significance levels (*p* value) * p<.05; ** p<.01; *** p<.001	

Table 8 Test statistics about use of instruments

Test name	Test statistics	Result	*P* value
Test Endogeniety of Life Satisfaction			
Durbin test	Chi^2 score	5.54**	0.02
Wu-Hausman test	F statistics	5.42**	0.02
Test relevance of the instruments			
F test on the three instruments	F statistics	11.07***	0.00
Test validity of the instruments			
Sargan and Basmann over-identification test	Chi^2 score	3.65	0.16
Significance level (*p* value): * p<.05; ** p<.01; *** p<.001			

5.3.4 Comparison between the OLS and second-stage 2SLS estimation results

Table 9 below provides a comparison of the OLS and the 2SLS estimate results in the second stage. Column (1) shows the same OLS estimation result as in Model 4 of Table 4, which used the entire sample population from all provinces with a sample size of 48814. Since the 2SLS estimation used data for Quebec only, the reasons being explained above, results of an

additional OLS estimation model with the same Quebec sample is provided in column (2) below for the purpose of comparing it with the second-stage 2SLS result in column (3).

Table 9 Comparison of OLS and 2SLS estimate results

Dependent variable: BMI	(1)	(2)	(3)
	OLS Model 4	Additional OLS Model	2SLS model
Independent variables	(The entire sample)	(Quebec sample only)	(Quebec sample only)
Life Satisfaction	-.321***	-.282***	-1.628**
Cognitive Health	.041	-.004	.397
Age	.227***	.214***	.192***
Male	.867***	1.611***	1.401***
Married	.940***	.645**	.934**
Visible Minority	-.363***	-.207	-.369
Income	-.042*	.086	.320**
Education	-.179**	-.325	-.472
Peer Group A (urban-rural mix, average percentage of Aboriginals and immigrants in population)	Reference	Reference	Reference
Peer Group B (mainly urban; high employment; low proportion of Aboriginal and higher than average immigrant population)	-.551***	(omitted)	(omitted)
Peer Group C (rural-urban mix, low percentage of immigrants in population)	.246**	.132	.298
Peer Group D (rural with high employment)	.240	(omitted)	(omitted)
Peer Group E (remote rural with high percentage of Aboriginals in population)	.221**	-.209	-.126
Peer Group F (northern remote with very high percentage of Aboriginals in population and low employment)	.638*	(omitted)	(omitted)
Peer Group G (largest metro with very low percentage of Aboriginals and high Percentage of immigrants in population)	-.699***	-.208	-.322
Peer Group H (northern rural with high percentage of Aboriginals in population)	1.076***	.436	.858
Peer Group I (rural with low	-.033	.071	.573

Dependent variable: BMI	(1)	(2)	(3)
Independent variables	OLS Model 4 (The entire sample)	Additional OLS Model (Quebec sample only)	2SLS model (Quebec sample only)
employment)			
Quebec	Reference		
New Brunswick	1.244***		
Saskatchewan	.917***		
British Columbia	-.126		
Nova Scotia	.807***		
Ontario	.655***		
Manitoba	.869***		
Alberta	1.043***		
Newfoundland (NFL)	1.582***		
Prince Edward Island (PEI)	.479		
Yukon, Nunavut & NWT	-.037		
Constant	25.403***	24.738***	32.91***
Number of observations	48814	2411	2411
F	160.51	14.08	11.35
r2_a	.08	0.07	0.10
		Significance levels (*p* value): * p<.05; ** p<.01; *** p<.001	

In column 3 of Table 9, the second-stage result of the 2SLS estimation shows that life satisfaction, when instrumented by sunny weather, availability of social support, and availability of transportation facilities, still has a significant negative impact on BMI after accounting for the impacts of the other covariates.

This impact of life satisfaction on BMI was also much stronger than that of a comparable OLS estimation result in column 2. There may be may be many reasons for the larger 2SLS estimates than the OLS estimates. Further research is required to understand why accounting for endogeneity has such a large impact on the parameter estimates.

The 2SLS estimation result along with the OLS and Logit results discussed before thus suggest that life satisfaction, as a subjective wellbeing measure, has a significant, negative, and independent impact on BMI, a finding consistent with the prediction of the Self-determination Theory and Wellbeing Theory.

Chapter 6
CONCLUSION AND POLICY IMPLICATION

This study combined the concepts of the theories of wellbeing such as the Self-determination Theory and the Wellbeing Theory, and the Social Cognitive Theory to investigate the independent role of subjective wellbeing in obesity. This study used Ordinary Least Square, Logistic, and Two-stage last square estimation techniques to analyze data from the Canadian Community Health Survey, 2010 wave. The study is important because it helps understand obesity from the perspective of subjective wellbeing, and provides possible cost-effective policy alternatives to curb the trend of rising obesity prevalence.

6.1 Theoretical contribution

First, the study was important in the sense that the research on subjective wellbeing is still new and none of the empirical studies in this field has carefully tested and established the exact relationship between subjective wellbeing and obesity measures involving Canadian data. This study tried to show that people's body mass index and the likelihood of being obese are not only affected by "who they are," "what they have," "which groups they belong to," and "where they live"; but also by "how people think and feel about their lives," in other words, the level of their life satisfaction. Thus this study has tried to add a new dimension to understanding obesity beyond conventionally studied determinants. In addition, as no study has carefully examined the causal pathway between obesity and subjective wellbeing, this study has tried to fill this literature gap by trying to establish the independent impact of life satisfaction on obesity using the instrumental variable two-stage least square technique.

6.2 Policy implication

Insights from this study may also be considered for design, implementation, and evaluation of public policy. The results of the study show that improving income and education levels of individuals may help reduce levels and prevalence of obesity. The results also show that even after controlling for conventionally studied demographic and socioeconomic covariates, life satisfaction has independent negative impact on BMI.

To battle obesity, governments in many parts of Canada have often relied on the lifestyle/behavioral change approach of public health intervention, which focus directly on changing behaviours of individuals. For example, there are subsidy programs to support healthy eating including the Food Mail Program for Northern Canada, the Northern Fruit and Vegetable Pilot Program in Ontario, and community-based food security initiatives. There are also financial incentives to promote physical activity including the Children's Fitness Tax Credit and the Federal Tax Credit for Public Transit in the income tax system (PHAC 2011, 33). Governments are debating on using financial disincentives such as taxes on "unhealthy" foods and beverages to influence individual health behavior but there are concerns about their design and implementation (Faulkner et al. 2011, 33).

However, these policies and public health interventions focus on the symptoms of obesity rather than the root cause of obesity and may not be sufficient for containing obesity prevalence, as obesity rates in Canada have been rising since the 1990s (PHAC 2011, 4; Statistics Canada 2012). Some of the policies, like Food Mail Programs, Fitness and Public Transit Tax Credits, etc., are also costly.

Considering the insufficiency of the existing intervention programs in controlling obesity, the finding about the independent role of life satisfaction may have some policy implications in

obesity, because it represents a shift in perspective of public health intervention — by attempting to look at the root causes of obesity rather than the symptoms. The theories summarized in chapter 3 suggest that compared with other methods, improved subjective wellbeing produces more sustainable productive behaviors (Deci and Ryan 2000). Therefore, improving subjective wellbeing in general can be used as a down-stream instrument to improve long-term health outcomes of citizens, as echoed in the prime message set out by the *World Happiness Report 2013* (Helliwell, Layard, and Sachs 2013).

However, the small effect of life satisfaction on BMI suggests that it is unlikely that policy makers will use subjective wellbeing as a major downstream policy instrument to battle the obesity problem; rather, subjective wellbeing is more likely to be treated as a general policy goal for a country. The Stiglitz Commission has emphasized including wellbeing as an end goal of national public policy—increasing the number of people living happy and fulfilling lives and flourishing (see Forgeard et al. 2009, 3; Stiglitz, Sen, and Fitoussi, 2009, 12). Helliwell, Layard, and Sachs (2012) have argued that income affects life satisfaction especially in poor societies, but other things like community trust, mental and physical health, the quality of governance, and rule of law, etc., matter even more in rich societies that have a low marginal utility of income. The United States and Denmark are two contrasting examples in this regard. The United States has experienced no rise in life satisfaction for half a century, a period in which inequality has soared, social trust has declined, and the public has lost faith in its government. On the other hand, Denmark is the happiest country in the world according to a Gallup World Poll taken in February 2012 (Sharpe and Capeluck 2012). In Canada, although Canadians are happy and getting happier (Sharpe and Capeluck 2012; Statistics Canada 2012), Canadian families are increasingly giving up leisure time and cultural activities with family and friends, both of which

are important for building social trust and resilience (see the report of the Canadian Index of Wellbeing Network 2012, 15).[5]

Although it is difficult and complex to design policies that target life satisfaction, the literature has suggested a number of ways to influence life satisfaction. Life satisfaction of individuals depends on access to life opportunities, social justice and various 'collective goods' — equitable distribution of economic and institutional resources, political freedom or opportunities for democratic engagement in allocating these resources, and family and community support etc. (see NEF 2008, 10; Raphael 2006). These factors increase social capital by encouraging trust, norms of reciprocity and participation. For example, encouraging family and social ties (such as encouraging marriage and remarriage after divorce) improves overall subjective wellbeing. Community economic development projects managed by the communities themselves can improve overall life satisfaction of residents through longer-term improvement in job quality and transferable skills, and by encouraging shared activities such as civic engagement and volunteering, etc., (Helliwell 2011b; Hoorn 2009). Encouraging voluntary participation in nature conservation, restoration of community gardens (e.g. in Vancouver) and public open spaces, and philanthropic activities increase all components of personal wellbeing like satisfying life, emotional wellbeing, functioning, resilience, self-esteem, vitality etc. (Helliwell 2006, 2011b; Michaelson et al. 2009). Peer engagement in school and teaching children how to enhance their own and others' well-being increase their future life satisfaction.

As the subjective wellbeing approach is rather new, there is no a definitive answer about whether this approach is more costly or more cost-effective than the other interventions. Helliwell (2011b, 12) has argued that improving subjective wellbeing delivers better long-term

[5] Canadian Index of Wellbeing Network is an independent non-partisan network of national and international leaders, researchers, organizations based in the Faculty of Applied Health Science at the University of Waterloo. The network's signature product, Canadian Index of Wellbeing (CIW), measures Canada's wellbeing and its progress.

outcomes at a lower cost, because public spending behind “prevention” yields more sustainable health benefits than quick fixes or “cures” (Helliwell, Layard, and Sachs 2013, 41-52). The reason is obvious, for example, getting people back to work is less costly and easier than creating new jobs; preventing mental illness by treatment like cognitive behavioural therapy is less costly than treating long lasting disability and chronic conditions that mental illness leads to; and improving personal subjective wellbeing in terms of resilience, self-esteem, vitality and functioning and trust by social prescriptions provides better productivity.

In summary, while this research indicates that life satisfaction does have an effect on BMI, this impact is not large and it is unlikely that policy makers will deliberately target life satisfaction as a means of reducing obesity. However, as policy makers are increasingly making life satisfaction a policy goal for a society, it will also have some positive impacts on problems such as obesity. This study also suggests that other policy measures, such as policies that improve education and income, are also important. In addition, much of the variation in BMI cannot be explained using the currently available data, which means that a full understanding of what affects obesity remains to be discovered and more effective evidence-based policies need to be designed in the future.

6.3 Limitations and future extension

Although this study provides interesting results and policy implications on the obesity issue, this study was limited in several aspects. First, as this study relies on self-reported data on BMI, the results may be susceptible to respondent (mood) and response bias. If the response is biased, for example, when obese women tend to underestimate their weight, the estimation residuals of the models may not be random, so the coefficients in the estimation results may be

biased. However, actual values of BMI would be impossible to measure for a large population and the respondent and response bias is less a problem when a large population sample (like in this study) is used (see NEF 2011, 17 in this regard). Second, data on other possible and better subset of instruments and other measures of subjective wellbeing were not collected by every province. This reality compromised the sample size in 2SLS estimation and constrained the potential of this study. More complete understanding of subjective wellbeing, thus, would be possible when complete data becomes available from all the provinces. Third, lack of panel data set constrained the prospects of conducting a longitudinal study. Panel data have the ability to model temporal effects from variables that vary over time. With panel data, it is also possible to control for unobserved differences between individuals that are constant over time (individual fix effects). Thus panel data reduce the collinearity among the explanatory variables and gives more precision in parameter estimates. Therefore, a future longitudinal study involving panel data set is expected to strengthen the findings of this study.

Finally, increasing the size of the common content of the Canadian Community Health Survey in the future would help researchers conduct more effective research on obesity. For example, collecting the same and broader range of variables from all provinces would help researchers find better instrumental variables and deepen the public's understanding of the causal pathway between subjective wellbeing and obesity. Similarly, collecting data from all provinces on the other measures of wellbeing (such as self-esteem, optimism, resilience, vitality, autonomy, competence, engagement, meaning and purpose, social trust, wellbeing at work, etc.) would allow researchers to test their specific roles in health outcome, and to provide relevant policy insights in more detail.

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APPENDIX

Table A1 Description of variables

Variable name	Description of variables
BMI	BMI (Weight/Hight^2) from 20 to 64 years of age (grouped in to 9 category at equal distance
Life satisfaction	Satisfaction with life in general is constructed from using a scale of 0 to 10, where 0 means "very dissatisfied" and 10 means "Very satisfied", by a question on how the respondent feel about life as a whole at the time of the survey.
Cognitive Health	This variable classifies respondents based on cognitive health status based on questions on ability to remember things and solve day-to-day problems. This variable is constructed from using a scale of 1 to 6, where 1 means "unable to remember thing, think clearly and solve day to day problems" and 6 means" able to remember things, think clearly and solve day to day problems". Higher score means greater ability to remember think and solve problem.
Age	In the CCHS micro data set, the respondents are categorized into 16 groups starting from age 12 to 80 years or over. However, the study sample takes only 9 out of 16 groups ranging from 20 years to 64 years, and these nine groups have age range of equal distance. Values with age range are: (1) 12 to 14 years, (2) 15 to 17 years, (3) 18 to 19 years, (4) 20 to 24 years, (5) 25 to 29 years, (6) 30 to 34 years, (7) 35 to 39 years, (8) 40 to 44 years, (9) 45 to 49 years, (10) 50 to 54 years, (11) 55 to 59 years, (12) 60 to 64 years, (13) 65 to 69 years, (14) 70 to 74 years, (15) 75 to 79 years, and (16) 80 years or above.
Male	Gender; Male=1; 0, otherwise.
Married	Sex: Married=1; 0, otherwise.
Education	Post-secondary graduation (degree/diploma) = 1, 0, otherwise
Income	This variable groups the total household income of the respondent from all sources at equal distance. Values: 1. No income or less than $20,000, 2. income from $20,000 to $39,999, 3. income from $40,000 to $59,999, 4. income from $60,000 to $79,999, 5. income from $80,000 or more.
Visible Minority	Culture & Race: Visible Minority=1 (Aboriginal or other visible minorities of different ethnic or racial origin, such as Chinese, Japanese, Korean, Arab, Pilipino, Black, Latin American, South Asian (e.g., East Indian, Pakistani, Sri Lankan), West Asian (e.g., Afghan, Iranian), and South east Asian (e.g., Cambodian, Indonesian, Laotian, Vietnamese); 0=white
Instrumental variables:	
Sunny weather	This variable implies the amount of sun the respondent is exposed to in his area. The question was whether the respondent use sunscreen on the face while in the sun for 30 minutes or more in 1 to 5 scales. Higher score means more use of sunscreen, i.e., more sunny weather.
Availability of transportation facility	This variable implies the availability of transportation facility. The respondents where asked whether they have not had the H1N1 flu shot due to Transportation problems; measured in a

Variable name	Description of variables
	2 point scale (1 yes; 2 no).
Availability of social support	This continuous variable implies availability of social support. Under the concept of social support availability, respondents were asked about how many close friends and close relatives they have, i.e., people they feel at ease with and can talk to about what is on their mind. Value: 0-99

Source: Author's compilation from the CCHS Annual Component 2010 Questionnaire; the CCHS Annual Component, Public Use Micro Data File (PUMF) 2010; and CCHS: Data Dictionary (codebook) 2010.

Table A2 Definition of Peer Groups

Peer Group	Health regions	Socio-economic/demographic characteristics	% of sample	*Notes*
A	Quebec: La Capitale-Nationale, La Outaouais, De Laval, La Montérégie. Saskatchewan: Regina, Saskatoon; British Columbia: Okanagan, Fraser East, South Vancouver, Central Vancouver; Nova Scotia: Zone 6; Ontario: Brant Cont, City Hamilton, Hastings & Prince Edward Counties, Chatham-Kent, Kingston, Frontenac and Lennox and Addington, Lambton, Middlesex-London, Niagara, Peterborough. Manitoba: Winnipeg, Brandon; PIE: Queens County, Alberta: South Zone;	1. Urban-rural mix from coast to coast 2. Average percentage of Aboriginal population 3. Average percentage of immigrant population 4. Above average employment rate	33.5	
B	British Columbia: Fraser North, Fraser South, Richmond, North Shore/Coast Garibaldi; Ontario: Durham, Halton, City of Ottawa, Peel, Waterloo, Wellington-Dufferin-Guelph, Windsor-Essex, York; Alberta: Calgary, Edmonton;	1. Mainly urban centres with above average population density 2. Low proportion of Aboriginal population 3. Very High employment rate 4. Higher than average percentage of immigrant population	16.7	
C	Ontario: District of Algoma, North Bay Parry Sound District, Sudbury, Thunder Bay, Timiskaming. New Brunswick: Zone-1, 2, & 3; Quebec: du Bas-Saint-	1. Sparsely populated urban-rural mix in Eastern and Central provinces 2. Average percentage of Aboriginal population	10.3	

Peer Group	Health regions	Socio-economic/demographic characteristics	% of sample	*Notes*
	Laurent, du Saguenay - Lac-Saint-Jean, de la Mauricie, de l'Estrie, Abitibi-Témiscamingue British Columbia: Kootenay-Boundary, Thompson/Cariboo, North Vancouver Island. New Foundland: Eastern region; Prince Edward Island: Prince County. Nova Scotia: Zone 1, 2, 3 & 4;	3. Average employment rate 4. Low percentage of immigrant population		
D	Saskatchewan: Sun Country and Five Hills, Sunrise and Kelsey Trail, Heartland; Prince Edward Island: Kings County; Manitoba: Central, Assiniboine & Parkand region	1. Mainly rural regions 2. Average percentage of Aboriginal population 3. High employment rate	5.1	*Has some elements of peer group H. In our dataset, Heartland health Region data is combined with Prairie North health region data which belongs to Peer Group H*
E	Quebec: La Chaudière-Appalaches, de Lanaudière, des Laurentides. Ontario: Elgin-St. Thomas Health Unit, Grey Bruce, Haldimand-Norfolk, Haliburton, Kawartha, Pine Ridge District, Huron County, Leeds, Grenville and Lanark District, Oxford County, Perth District, Renfrew County, Eastern Ontario, Simcoe Muskoka District. British Columbia: East Kootenay Manitoba: North Eastman, South Eastman, Interlake. Alberta: Central & north zone.	1. Mainly rural and remote regions in the Western provinces and the territories 2. High proportion Aboriginal population 3. Average percentage of immigrant population	3.1	

Peer Group	Health regions	Socio-economic/demographic characteristics	% of sample	*Notes*
F	Saskatchewan: Mainly Mamawetan /Keewatin/ Athabasca Health Region	1. Northern and remote regions 2. Very high proportion of Aboriginal population 3. Very low employment rate 4. Low proportion of immigrants	0.4	*Has some elements of peer group C. In the dataset, Mamawetan /Keewatin/ Athabasca Health Region data is combined with Prince Albert health region data which belongs to Peer Group C*
G	Quebec: Montréal Ontario: City of Toronto British Columbia: Vancouver	1. Largest metro centers with an average population density of 4,065 people per square kilometer 2. Very Low proportion of Aboriginal population 3. Average employment rate 4. Very high proportion of immigrant population	15.6	
H	Quebec: Côte-Nord Ontario: Porcupine British Columbia: North West, Northern Interior and North East. Manitoba: Nor-Man Yukon	1. Rural northern regions from coast to coast 2. High proportion of Aboriginal population 3. Low proportion of immigrants	2	
I	New Brunswick: Zone 4,5,6 &7. Quebec: la Gaspésie	1. Mainly rural Eastern regions 2. Average percentage of Aboriginal population 3. Low employment rate 4. Very Low percentage of immigrant population	*1.7*	*Has some elements of peer group C. In the dataset, New Brunswick Zone 4 and 5 is combined to form one zone (Zone 4) and Zone 5 & 6 is combined to form another zone (Zone 5). Zone 4 belongs to Peer Group ,) but Zone 5, 6 & 7 belongs to Peer Group I. So, This peer group predominantly belongs to CCHS Peer Group I.*

Source: Author's compilation from Statistics Canada publication: 82-221-X

Note: The composition of the peer groups in the above table are taken from Statistics Canada publication: 82-221-X: 2007 Health Region Peer Groups – User Guide and its appendix B: Descriptive Statistics for Final Peer Groups, appendix C: Descriptive Summary of Final Peer Groups, and appendix D: Health Region Peer Groups; http://www.statcan.gc.ca/pub/82-221-x/2011002/regions/hrpg2007-eng.htm; http://www.statcan.gc.ca/pub/82-221-

x/2011002/regions/app-ann/app2-ann2-eng.htm; http://www.statcan.gc.ca/pub/82-221-x/2011002/regions/app-ann/app3-ann3-eng.htm; and http://www.statcan.gc.ca/pub/82-221-x/2011002/regions/app-ann/app4-ann4-eng.htm, all accessed: 26 July 2010)

Table A3 Association between BMI and health behaviours and association between subjective wellbeing and health behaviours

Dependent variables:	BMI	Physical Activity (Daily energy expenditure in transportation & leisure)	Food habit (Daily intake of fruit & vegetables)
Independent variables:			
Health Behaviours			
Physical activity (daily leisure time energy expenditure	-.265***		
Eating Habit (fruit and vegetable intake)	-.085***		
Subjective wellbeing indicators			
Life Satisfaction		.174***	.133***
Cognitive health		.058***	.102***
Other factors			
Age	.192***	-.132***	-.004
Male	.923***	.337***	-.754***
Married	.762***	-.350***	-.006
Visible Minority	-.432***	-.155***	-.087**
Income	-.061**	.101***	.115***
Education	-.069	.259***	.380***
Peer Group A (urban-rural mix, average percentage of Aboriginals and immigrants in population)	Reference	Reference	Reference
Peer Group B (mainly urban; high employment; low proportion of Aboriginal and higher than average immigrant population)	-.531***	-.096**	-.040
Peer Group C (rural-urban mix, low percentage of immigrants in population)	.254**	.043	-.044
Peer Group D (rural with high employment)	.102	-.173*	-.076
Peer Group E (remote rural with high percentage of Aboriginals in population)	.189*	-.076*	-.048
Peer Group F (northern remote with very high percentage of Aboriginals in population and low employment)	.819**	.263*	-.277
Peer Group G (largest metro with very low percentage of Aboriginals and high percentage of immigrants in population)	-.662***	-.132**	.080
Peer Group H (northern rural with high percentage of Aboriginals in population)	1.009***	-.218***	-.082
Peer Group I (rural with low employment)	-.003	.094	.223**

Dependent variables:	BMI	Physical Activity (Daily energy expenditure in transportation & leisure)	Food habit (Daily intake of fruit & vegetables)
Quebec	Reference	Reference	Reference
New Brunswick	1.171***	.038	-.871***
Saskatchewan	.980***	.309***	-.623***
B. Columbia	.073	.756***	-.496***
Nova Scotia	.782***	.244***	-.966***
Ontario	.782***	.457***	-.511***
Manitoba	.953***	.371***	-.926***
Alberta	1.159***	.407***	-.568***
NFL	1.462***	.051	-1.417***
PEI	.527	.079	-.917***
Yukon, N. W. Territory & Nunavut	.154	.506***	-.588***
Constant	24.382***	.999***	3.532***
Number of observations	47310	50065	48814
F	168.51	250.96	122.56
Adjusted R^2	0.08	0.11	.06

Significance levels: * p<.05; ** p<.01; *** p<.001